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THE CORRELATION OF FRACTURE TOUGHNESS WITH CHARPY V-NOTCH IMPACT TEST DATA

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Fracture toughness data is compared with the Charpy V-notch impact data. The applicability of various regression models for showing the relationship of K_{Ic} with other mechanical properties is examined for gun steel. The types of material were classified by steel maker, type of forging, and location within the tube. It was concluded that, of the models examined, $K_{Ic}^2 = 5\ CVN\ \sigma_{ys} - .25\ \sigma_{ys}^2$, the Barsom-Rolfe correlation, provided the best correlation of K_{Ic} with mechanical property data. However, even then, the prediction of K_{Ic} was only within 6 - 18 percent of the measured value.

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INTRODUCTION

Usually, when a component or structure is designed to withstand high loads, e.g., a gun tube, there will be a mechanical property test included to measure notch toughness.* Regardless of the type of specimen used, the general purpose of the various kinds of notch toughness tests is to model the behavior of actual structures so that the laboratory test results can be used to predict service performance. A common feature of these toughness tests is to produce fracture in steels under carefully controlled laboratory conditions. Hopefully, the results of the tests can be closely related with service performance to establish levels of material property acceptance, e.g. military specifications for gun tube components. However, the basic drawback of such tests is that the results, which are usually expressed in terms of energy, fracture appearance, or deformation, cannot be translated into quantitative design and engineering parameters such as fatigue life or tolerable flaw size.

The development of linear elastic fracture mechanics (LEFM) makes it possible to characterize the fracture behavior in structural parameters that can be used directly by the engineer, namely, stress and flaw size. LEFM will be described and explained more fully later, but a number of pertinent points may be set out here. LEFM is based on a stress analysis and, thus, does not depend on the use of extensive service experience to translate laboratory results into practical design information. The results of an LEFM

*Notch toughness is defined as the ability of a material to absorb energy, usually when loaded dynamically, in the presence of a flaw, whereas toughness of a material is defined as the ability of a smooth member (un-notched) to absorb energy, usually when loaded slowly.

analysis for a particular application will yield the combinations of stress level and flaw size that would be required to cause fracture or, conversely, the stress level which can be tolerated without danger of fracture. In addition, fracture mechanics can be used to analyze the growth of small cracks (by stress corrosion cracking, corrosion fatigue, or fatigue) to critical size. Conceptually, the engineer can then quantitatively establish allowable stress levels and inspection requirements so that fractures cannot occur. Additionally, fracture mechanics can take into account the effect of temperature and loading rate on stress structures which contain flaws.

Therefore, fracture mechanics has several very definite advantages compared with traditional notch toughness tests and offers the designer, who has a foreknowledge (or estimate) of stress and flaw size, a method for quantitatively designing to prevent brittle fracture in gun tubes.

Besides aiding the designer, LEFM has the potential to aid the quality control engineer to ensure a fracture-safe component. However, LEFM is limited in this respect for several reasons. The cost of machining, fatigue pre-cracking, and testing of a K_{I_c} specimen and the size requirements necessary to insure valid K_{I_c} test results, render the test impractical as a quality control tool. Consequently, the need exists to correlate K_{I_c} data with test results obtained with less costly conventional mechanical property specimens. The most commonly used is the Charpy V-notch test because the test is conducted rapidly, is inexpensive, and the specimens are relatively easy to obtain. Various correlations can be developed if the limitations of the types of tests involved are understood. While no theoretical basis exists for most of the correlations, some conceptual basis is provided by similarities between fracture toughness and other mechanical property tests. Thus,

an understanding of the tests, what their measurements represent, and what variables influence the tests is important to obtain before developing or analyzing a correlation between the two tests.

LEFM

The purpose and usefulness of LEFM has already been discussed. This section defines and discusses the subject in more detail and presents what factors influence the fracture toughness of a material as defined by LEFM. It is intended as an overview and may be passed over by those familiar with the subject.

To borrow a definition from Barsom and Rolfe:

> "LEFM technology is based on an analytical procedure that relates the stress-field magnitude and distribution in the vicinity of a crack tip to the nominal stress applied to the structure, to the size, shape, and orientation of the crack or crack-like discontinuity, and to the material properties."

The underlying principle of the LEFM is that stress is intensified at the tip of a crack and may be expressed as a stress intensity factor, K. The general stress intensity factor relation may be expressed as

$K = f(g) \quad \sigma\sqrt{\alpha}$ where

K = stress intensity, (KSI $\sqrt{\text{in}}$)

f(g) = a parameter which depends upon the geometry of the crack and the stressed member.

σ = applied nominal stress (KSI)

α = crack length (in)

A second underlying principle of fracture mechanics is that unstable fracture occurs when the stress-intensity factor at the tip of a crack reaches a critical value, K_c, which is a material property. Thus, these

two principles establish three primary factors which control the susceptibility of a structure to brittle failure and which may be set into a simple mathematical relation. These are material toughness, the crack (size, geometry, and orientation), and the nominal applied stress. Other factors, e.g. loading rate, temperature, etc. simply affect the three primary factors.

We are usually concerned with an applied tensile nominal stress, either by tensile loading or by a bending moment. For a tensile displacement (Mode I deformation) and for small crack tip plastic deformation (plane-strain conditions), the critical stress intensity factor for fracture instability is designated K_{I_c}. This represents the inherent ability of a material to withstand a given stress field intensity at the tip of a crack and to resist progressive tensile crack extension under plane-strain conditions, i.e., K_{I_c} represents the fracture toughness of the material.

There are two useful ways of visualizing the concept of K_{I_c} stress intensity relation. First, there is an analogy between the applied load (P), nominal stress (σ), and yield stress (σ_{ys}) in an unflawed structural member and among the applied load (P), stress intensity (K_I) and critical stress intensity for fracture (K_{I_c}) in a structural member with a flaw. In an unflawed structural member, as the load is increased, the nominal stress increases until an instability (yielding at σ_{ys}) occurs. As a load is increased in a structural member with a flaw, the stress intensity, K, increases until an instability (fracture at K_{I_c}) occurs. A second visualization is that for a given material toughness, as defined by LEFM, there are many combinations of stress and flaw size which will result in fracture as shown in the schematic diagram below:

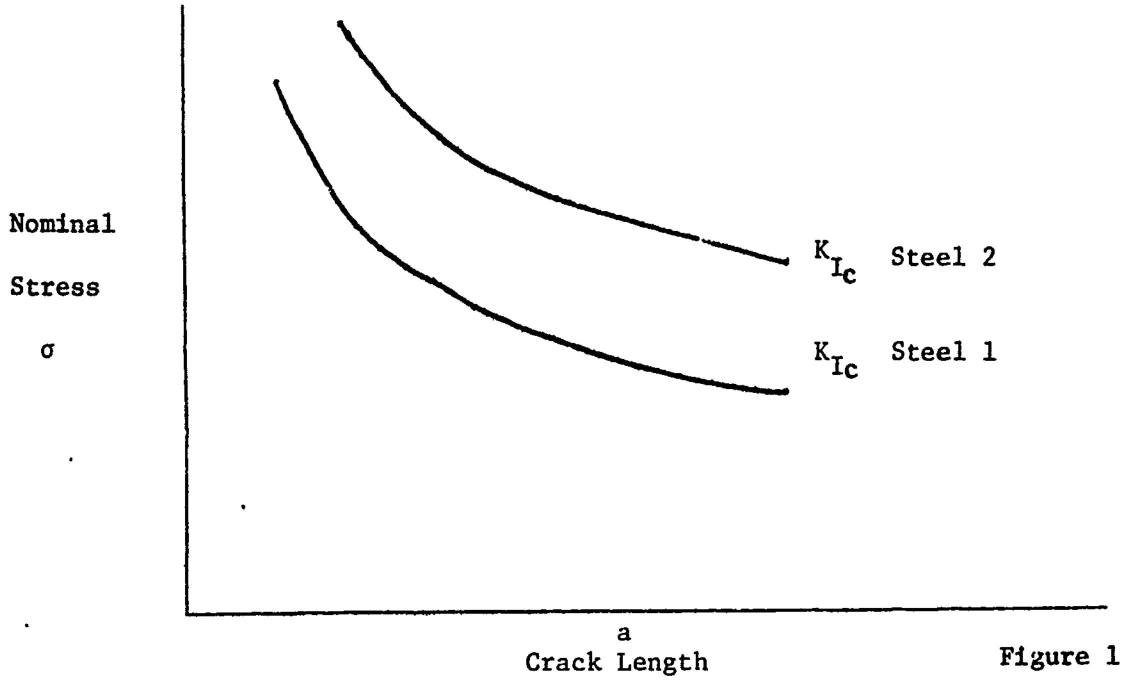


Figure 1

Schematic relation between stress, flaw size, and material toughness.

This diagram reflects that if a tougher steel is used, (steel 2), the tolerable flaw size increases significantly, particularly at lower applied nominal stress levels. This is a reflection of the one half power dependence of $K_{I\,c}$ upon a, the crack size.

The value of K_{Ic} is not only dependent upon the type of steel, but it is also a function of temperature, loading rate, and constraint. A schematic diagram illustrating the effect of temperature and loading rate upon fracture toughness is shown below:

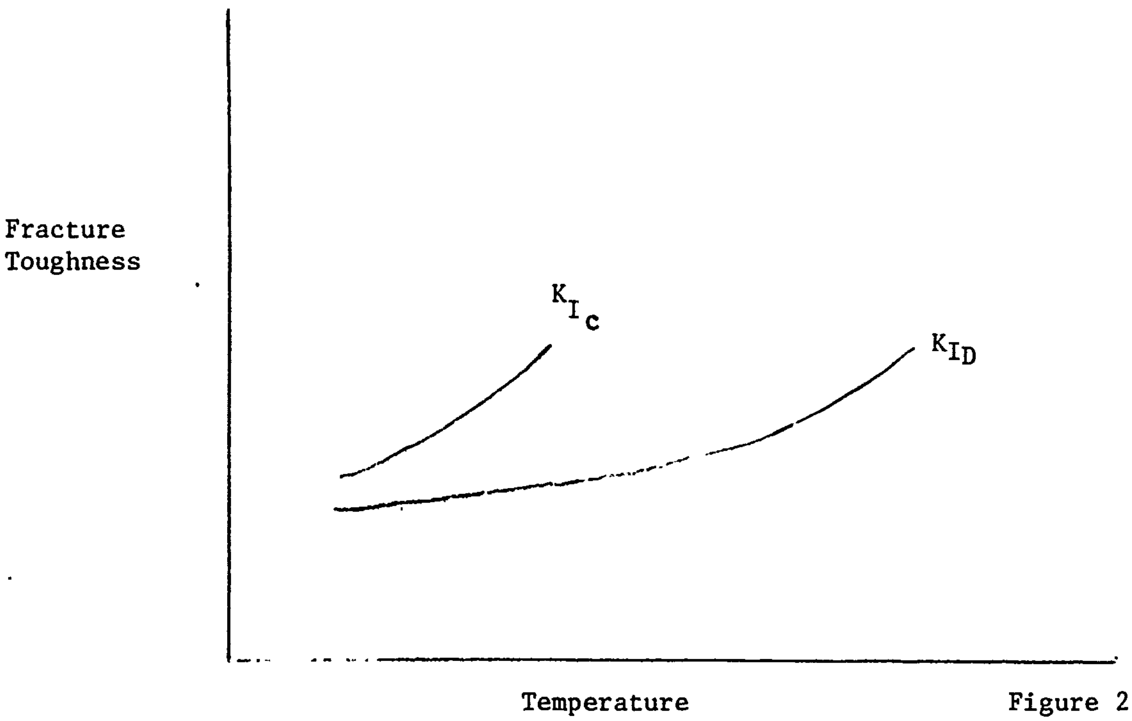


Figure 2

Schematic illustration of change in K_{Ic} and K_{ID} with temperature.

These graphs show that, in general, fracture toughness decreases with increasing loading rate as evidenced by K_{Ic}, K_{ID}, and decreasing temperature. Figure 2 also displays the effect of a transition temperature, i.e. at a particular temperature, the rate of change of K_{Ic} with temperature increases. This transition temperature is usually associated with a change from cleavage

to ductile tear. Additionally, a second transition with temperature exists. This is a transition in stress state from plane-strain to plane-stress as the constraint at the crack tip decreases due to crack tip blunting.

Notch toughness in an LEFM test also increases as constraint increases. Take, for example, a test bar loaded in tension with a single edge notch. At the tip of the notch, the plastic zone can increase in size only if contraction occurs in the lateral direction. This lateral contraction is constrained by the surrounding elastically stressed material which deforms to a smaller extent than a plastically deformed volume of material. Thus, the material in the plastic zone is constrained by reactive stresses leading to a triaxial state of stress which reduces the shearing stresses. The result is a restriction to plastic flow as shown in the schematic diagram below of a flow stress curve:

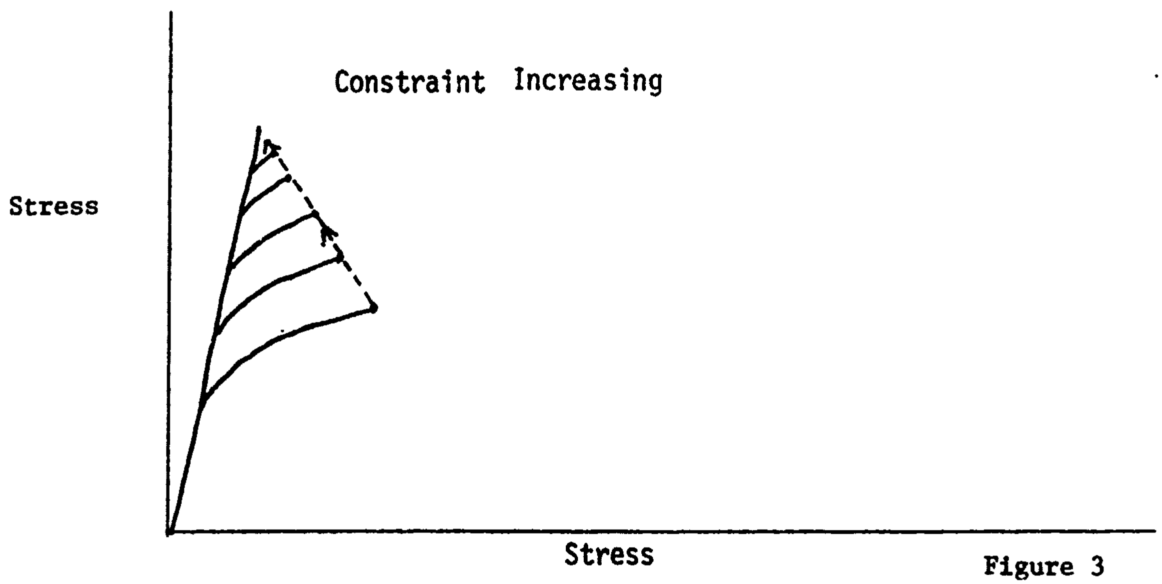


Figure 3

Elevation of Flow Curves

Thus constraint is increased by a sharper notch (smaller plastic zone) or by a thicker specimen (greater volume of elastically deformed material).

<u>CVN</u>: In contrast to fracture toughess testing, the Charpy V-notch impact tonghness testing procedure is well known and the results easily interpreted. Instead of describing the test, it is more practical to compare the usefulness of the test with LEFM. Although it is frequently used, there are many valid criticisms of this test in comparison with the K_{I_c} test. These are its blunt notch, its small size, its non-differentiation between crack initiation and crack propagation. However, the Charpy V-notch test is fast, inexpensive, commonly accepted, and easy to conduct. These attributes render the test ideal for correlation purposes.

Further, the following observations from several investigations suggest that it is possible to establish empirical correlations between K_{I_c} and CVN test results:

1. Clausing showed that the state of stress at fracture initiation in the CVN impact specimen is plane-strain, which is the state of stress in a thick K_{I_c} specimen.[1]

2. Holloman has shown that for the dimensions used in the CVN specimen, the maximum possible lateral stress is obtained, indicating a condition approaching maximum constraint.2

3. Barsom and Rolfe established that the effect of temperature and rate of loading on CVN and K_{I_c} is the same.[3]

4. In the upper shelf region the effects of loading rate and notch acuity are not so critical as in the transition temperature region.[4]

These statements provide the conceptual basis for the investigation outlined below:

References are listed at the end of this report.

PROCEDURE

Fracture toughness tests were conducted for the following sets of material obtained from 105mm M68 gun tubes. The tests were conducted according to ASTM Standard for C-shaped K_{I_c} specimens, E399-79

1. Cabot ESR - rotary forged - muzzle and breech
2. Cabot VD - rotary forged - muzzle and breech
3. Cabot VD - conventionally forged - breech
4. National Forge VD - rotary forged - muzzle and breech

Other mechanical property data (tensile strength, Charpy impact, %RA) were collected and tabulated for these sets of steel. This data is presented in the Appendix.

Now the problem becomes one of developing a correlation between K_{I_c} and CVN data and/or other mechanical property data. When one is faced with developing a relationship between sets of data, the statistical procedure is two-step:

1. Choosing the appropriate form of the relationship.
2. Determining how much confidence one can place in the predicted response of the relationship.

The form of the relationship may be chosen on the basis of the square of the correlation coefficient, R^2 (R^2 x 100 may be defined as the percent of variation explained by the regression model) or theoretical expectations on what the form of the relationship should be, e.g., an Arhennius relationship for energy activated phenomena. In this investigation several different models were investigated, conceptual in nature as well as strictly empirical. Confidence tests were performed on the regression model parameters and the predicted response. Additionally, the data and regression

residuals were examined to determine the validity of a Gaussian distribution and where improvements might be made in the correlation.

RESULTS AND DISCUSSION

The models that the data were fitted to are presented in Table I. The independent variables were -40°F and 70°F Charpy impact toughness (-40°F CVN and 70°F CVN, respectively), 0.1% offset yield strength (YS) and percent reduction in area (R.A.). The nonlinear models were transformed into linear equations by use of natural logarithmic transformations. Note that this transformation assumes the transformed residuals distributed normally as well. The data from all sets of material was lumped together in this evaluation of models. Note that the last two models are linear and multiple regression models utilizing the same equation.

$$\frac{K_{I_c}^{\,2}}{\sigma_{ys}^{\,2}} = \frac{5}{\sigma_{ys}} \left[CVN - \frac{\sigma_{ys}}{20}\right] \quad \text{or rearranging terms}$$

$$K_{I_c}^{\,2} = 5\ CVN\ \sigma_{ys} - .25\ \sigma_{ys}^{\,2}$$

This is the Barsom-Rolfe upper -shelf correlation between K_{I_c} and room temperature Charpy impact toughness and 0.1% offset yield strength. On the basis of the square of the correlation coefficient and the conceptual relationship between the independent and dependent variables, the best model was chosen. By looking at Table I it is seen that the Barsom-Rolfe correlation is the "best" model for this set of data. This relation holds for steels with yield strengths greater than 100 Ksi. It appears to hold for a wide number of steels and toughness ranges.[5] Part of the atractiveness of utilizing this relation is that it appears to have some theoretical basis. Paris[6] states:

"This paper (J. integral) finally explains the reasonableness of the Barsom-Rolfe correlation of upper-shelf Charpy values, CVN, with

TABLE I

VARIOUS REGRESSION MODELS

	n	R^2
$K_{Ic} = b_1$ CVN $(-40^oF) + b_2$	83	.124
$K_{Ic} = b_1$ CVN $(70^oF) + b_2$	83	.112
$K_{Ic} = b_1 \sigma_{YS} + b_2$	83	.132
K_{Ic} = R.A. + b_2	83	.012
$K_{Ic} = b_1 \sigma_{YS} b_2$ R.A. b_3	83	.347
$K_{Ic} = b_1 \sigma_{YS} b_2$ CVN (70^oF) b_3	83	.142
$K_{Ic} = b_1 \sigma_{YS} b_2$ CVN (-40^oF) b_3	83	.024
$K_{Ic} = b$ (σ_{YS} R.A.)b_2 CVN (70^oF) b_3	83	.138
$K_{Ic} = b_1 \sigma_{YS} + b_2$ CVN $(70^oF) + b_3$	83	.420
$K_{Ic} = b_1 \sigma_{YS} + b_2$ R.A. $+ b_3$	83	.144
$K_{Ic} = b_1[\,5\ \sigma_{YS}\ \mathrm{CVN} - \sigma_{YS}^{\ 2}\,]^{1/2} + b_2$	83	.634
$= b_1$ (B.R. K_{Ic}) $+ b_2$		
$K_{Ic}^{\ 2} = b_1$ CVN $\sigma_{YS} + b_2 \sigma_{YS}^{\ 2} + b_3$	83	.643

K_{I_c} numbers; that is,

$$\frac{K_{I_c}^2}{\sigma_{ys}} = \frac{5}{\sigma_{ys}} \quad CVN - \frac{\sigma_{ys}}{20}$$

This equation relating CVN, a limit-load relating energy parameter, to K_{I_c} is not only now acceptable but is, for us, in agreement with the J-failure criteria."

At this point it was decided to perform a stepwise regression analysis using the Barsom-Rolfe relation ($K_{I_c}2$ - $5CVN\sigma_{ys}$ - $.25\sigma_{ys}2$) as well as a simple linear regression of K_{I_c} with a K_{I_c} predicted by the Barsom-Rolfe relation (B.R.K_{I_c}). With the former analysis the coefficients of the regression equation utilizing the data could be compared with those of Barsom-Rolfe. The second regression of K_{I_c} with K_{I_c} predicted by Barsom-Rolfe relation, is simpler in form, allows confidence envelopes of the predicted response to be plotted, and expresses the relationship in understandable units.

The results of the stepwise regression analysis are presented in Table II, separated on the basis of steel producer, refining process, forging process, and location in the tube. Ninety percent confidence levels and partial F-tests for the coefficients are presented in the Appendix. In all the regression equations presented in Table II, it is possible for the confidence interval chosen that the $\sigma_{ys}2$ coefficient could be -0.25 as in Barsom-Rolfe equation. However, the CVN σ_{ys} coefficient and constant term did not match the Barsom-Rolfe coefficients. However, no statistical analysis was performed upon the data used by Barsom-Rolfe in formulating the coefficients of the Barsom-Rolfe relation.[7] Thus, there are no confidence levels on their parameters, and, therefore, without further information it is not possible to conclusively state that the difference in the $\sigma_{ys}2$ coefficients is

TABLE II

STEPWISE MULTIPLE REGRESSION MODEL RESULTS

B.R. Model	$K_{Ic}^2 = 5CVN\sigma_{YS} - .25\ \sigma_{YS}^2$	n	R^2
C/ESR/RF/M	$K_{Ic}^2 = .03CVN\sigma_{YS} - .58\ \sigma_{YS}^2 + 7130$	9	.93
C/ESR/RF/B	$K_{Ic}^2 = .03CVN\sigma_{YS} - .24\ \sigma_{YS}^2 + 4290$	10	.71
C/VD/RF/M	$K_{Ic}^2 = .04CVN\sigma_{YS} - .17\ \sigma_{YS}^2 - 7855$	20	.77
C/VD/RF/B	$K_{Ic}^2 = .02CVN\sigma_{YS} - .32\ \sigma_{YS}^2 + 8764$	20	.72
C/VD/CF/B	$K_{Ic}^2 = .03CVN\sigma_{YS} + 2.0\ \sigma_{YS}^2 - 65050$	12	.59
NF/VD/RF/M	$K_{Ic}^2 = .01CVN\sigma_{YS} - 1.19\sigma_{YS}^2 + 35395$	9	.94
NF/VD/RF/B	$K_{Ic}^2 = .03CVN\sigma_{YS} + 2739$	3	.997
MUZZLE	$K_{Ic}^2 = .03CVN\sigma_{YS} - .27\ \sigma_{YS}^2 + 1807$	38	.81
BREECH	$K_{Ic}^2 = .01CVN\sigma_{YS} - .08\sigma_{YS}^2 + 9204$	45	.48
ALL DATA	$K_{Ic}^2 = .02CVN\sigma_{YS} + .15\ \sigma_{YS}^2 - 2928$	83	.64

C - Cabot
NF - National Forge
ESR - Electro Slag Refined
VD - Vacuum Degassed
RF - Fotary Forged
CF - Conventionally Forged
B - Breech
M - Muzzle

significant. Secondly, the analysis deals with data in a fairly narrow range (160 - 180 Ksi Y.S., 15-30 ft. lbs. CVN, 105 - 135 Ksi $\sqrt{in}$ K_{I_c}). The data of Barsom-Rolfe represented a number of steels and thus the coefficients between sets of different steels may be expected to differ although the basic form of the relationship may still hold. A second point to be made is that the muzzle data shows much better fit to the B-R model. The reason for this is not clear.

Table III presents the results of regressing the B-R predicted K_{I_c} with the actual K_{I_c} measurement. Ninety percent confidence envelopes about the predicted response are shown in Figures 4-13. The results of this regression analysis support the results of the stepwise analysis. That is, the coefficients (except in the first three and the "muzzle" regression equations) do not match those of the Barsom-Rolfe relation. Again the muzzle data showed a better fit to the Barsom-Rolfe equation than the breech data.

A third computer program was utilized to examine the residuals (see the Appendix for the results). This examination showed that the assumption of Gaussian distribution of errors is acceptable. This regression analysis also forced the constant term to zero in order to again compare the constants with those of Barsom-Rolfe relation. This analysis supported the results of the simple linear regression analysis, i.e., only the muzzle regression coefficients could possibly be that of Barsom-Rolfe relation.

At this point in the discussion it is prudent to note several cautions involving the statistics used and their interpretation. First, linear regression <u>does not</u> give cause and effect statements, only a relationship between data sets. Second, one may fit a more accurate equation between sets of data by using more terms in the equation, but there may be considerable error involved in extrapolating the results outside the range of data or applying

TABLE III

LINEAR REGRESSION MODEL RESULTS

B.R. Model $K_{Ic} = (5\,\sigma_{CVN\,YS} - \frac{\sigma_{YS}^2}{4})^{1/2} + 0$

		n	R^2
	$K_{Ic} = K_{Ic}\,(BR) + 0$		
C/ESR/RF/M	$K_{Ic} = 1.09\ K_{Ic}(BR) - 8.7$	9	.93
C/ESR/RF/B	$K_{Ic} = .75\ K_{Ic}(BR) + 31.4$	10	.67
C/VD/RF/M	$K_{Ic} = 1.30\ K_{Ic}(BR) - 23.1$	20	.74
C/VD/RF/B	$K_{Ic} = .72\ K_{Ic}(BR) + 43.8$	20	.72
C/VD/CF/B	$K_{Ic} = .50\ K_{Ic}(BR) + 63.1$	12	.42
NF/VD/RF/M	$K_{Ic} = .55\ K_{Ic}(BR) + 45.8$	9	.87
NF/VD/RF/B	$K_{Ic} = .61\ K_{Ic}(BR) + 74.2$	3	.996
MUZZLE	$K_{Ic} = .98\ K_{Ic}(BR) + 8.5$	38	.81
BREECH	$K_{Ic} = .38\ K_{Ic}(BR) + 79.9$	45	.45
ALL DATA	$K_{Ic} = .65\ K_{Ic}(BR) + 45.7$	83	.63

Fig. 4. REGRESSION OF B.R. K_{Ic} UPON K_{Ic} WITH 90% CONFIDENCE ENVELOPES; Cabot, ESR, rotary forged, breech data.

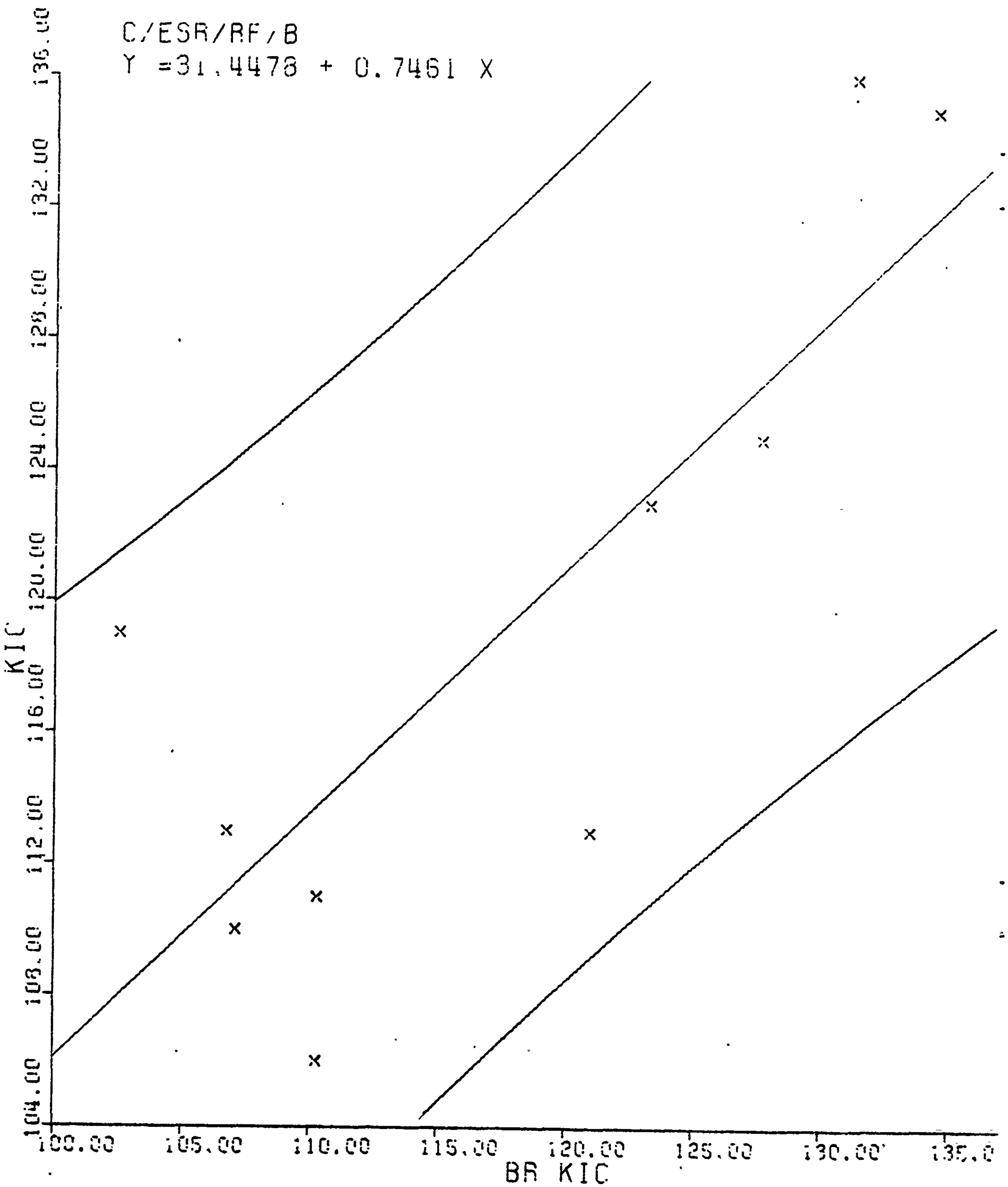


Fig. 5. REGRESSION OF B.R. K_{Ic} UPON K_{Ic} WITH 90% CONFIDENCE ENVELOPES; Cabot, ESR, rotary forged, muzzle data.

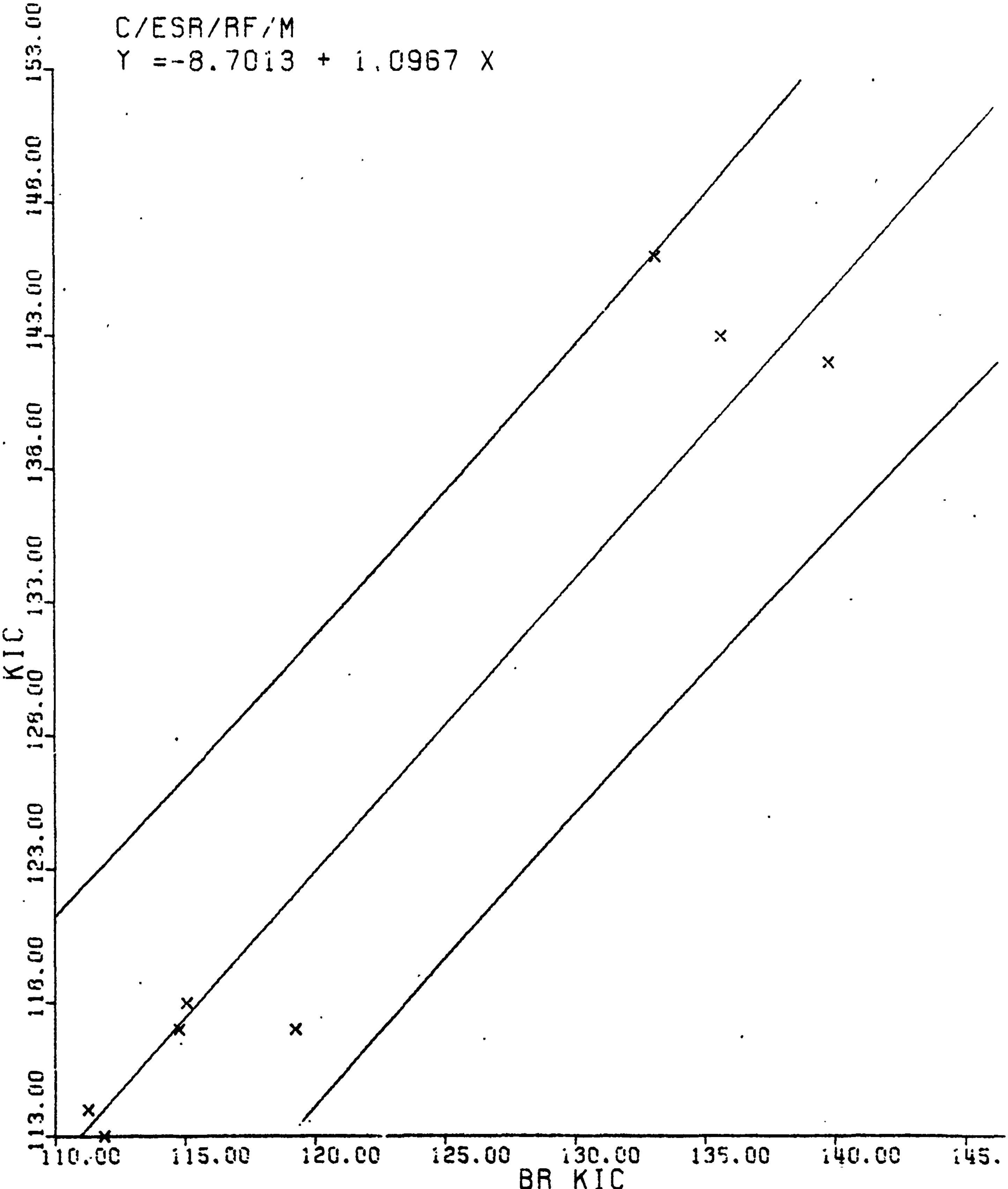


Fig. 6. REGRESSION OF B.R. K_{I_c} UPON K_{I_c} WITH 90% CONFIDENCE ENVELOPES; Cabot, Vacuum-Degassed, rotary forged, breech data.

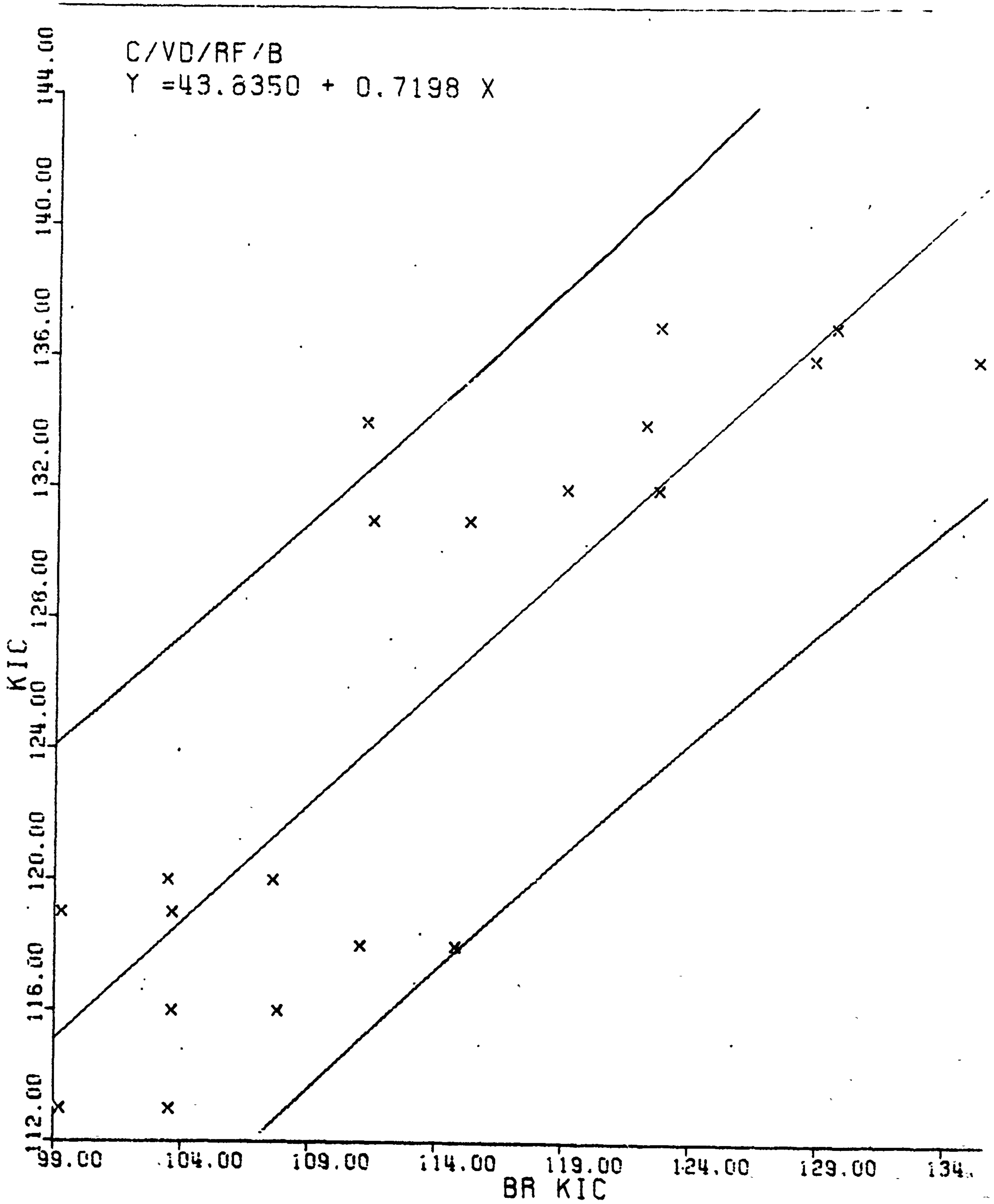


Fig. 7. REGRESSION OF B.R. K_{I_c} UPON K_{I_c} WITH 90% CONFIDENCE ENVELOPES; Cabot, Vacuum-Degassed, rotary forged, muzzle data.

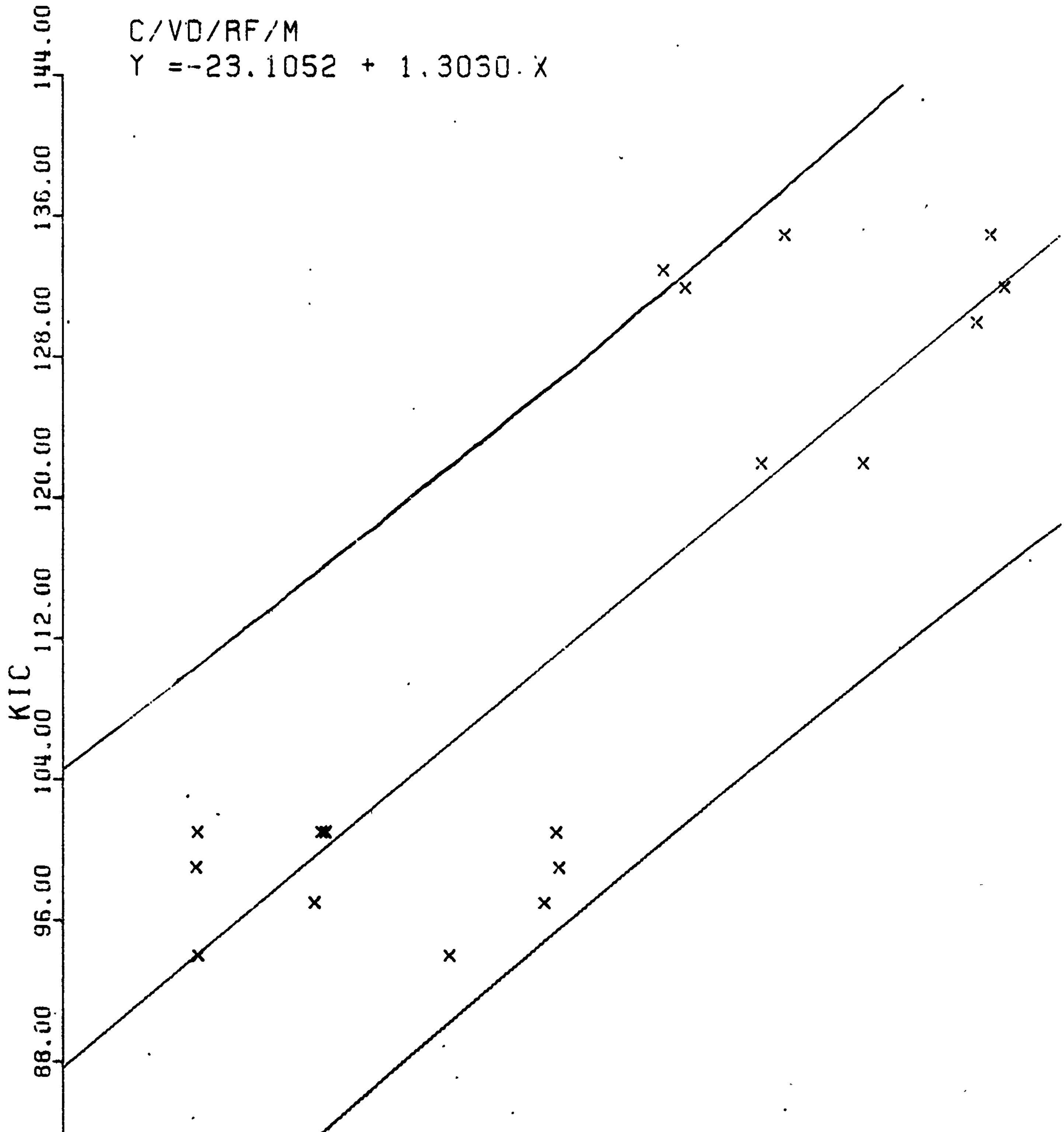


Fig. 8. REGRESSION OF B.R. K_{Ic} UPON K_{Ic} WITH 90% CONFIDENCE ENVELOPES; Cabot, Vacuum-Degassed, conventionally forged, breech data.

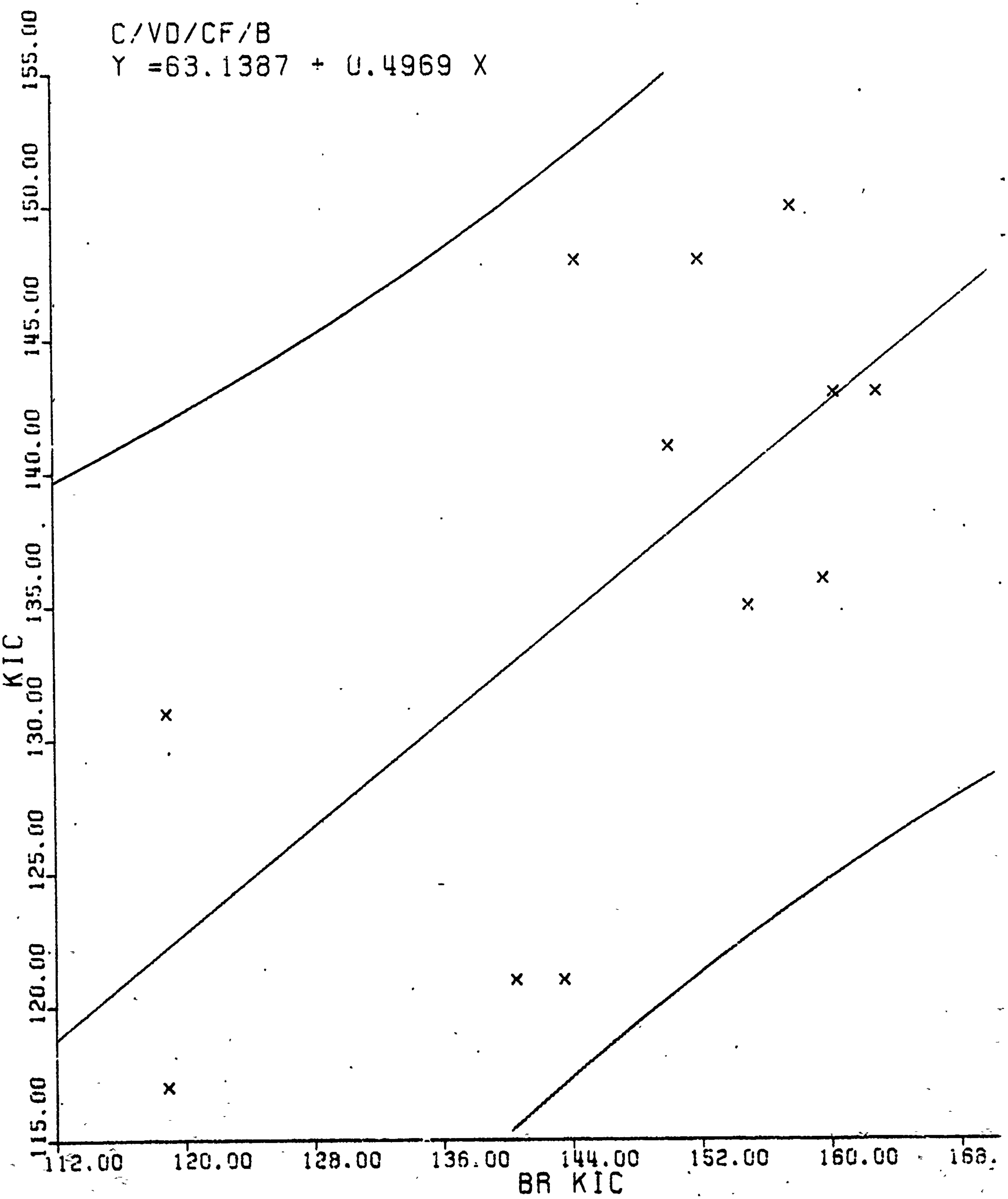


Fig. 9. REGRESSION OF B.R. K_{Ic} UPON K_{Ic} WITH 90% CONFIDENCE ENVELOPES; National Forge, Vacuum-Degassed, rotary forged, muzzle data.

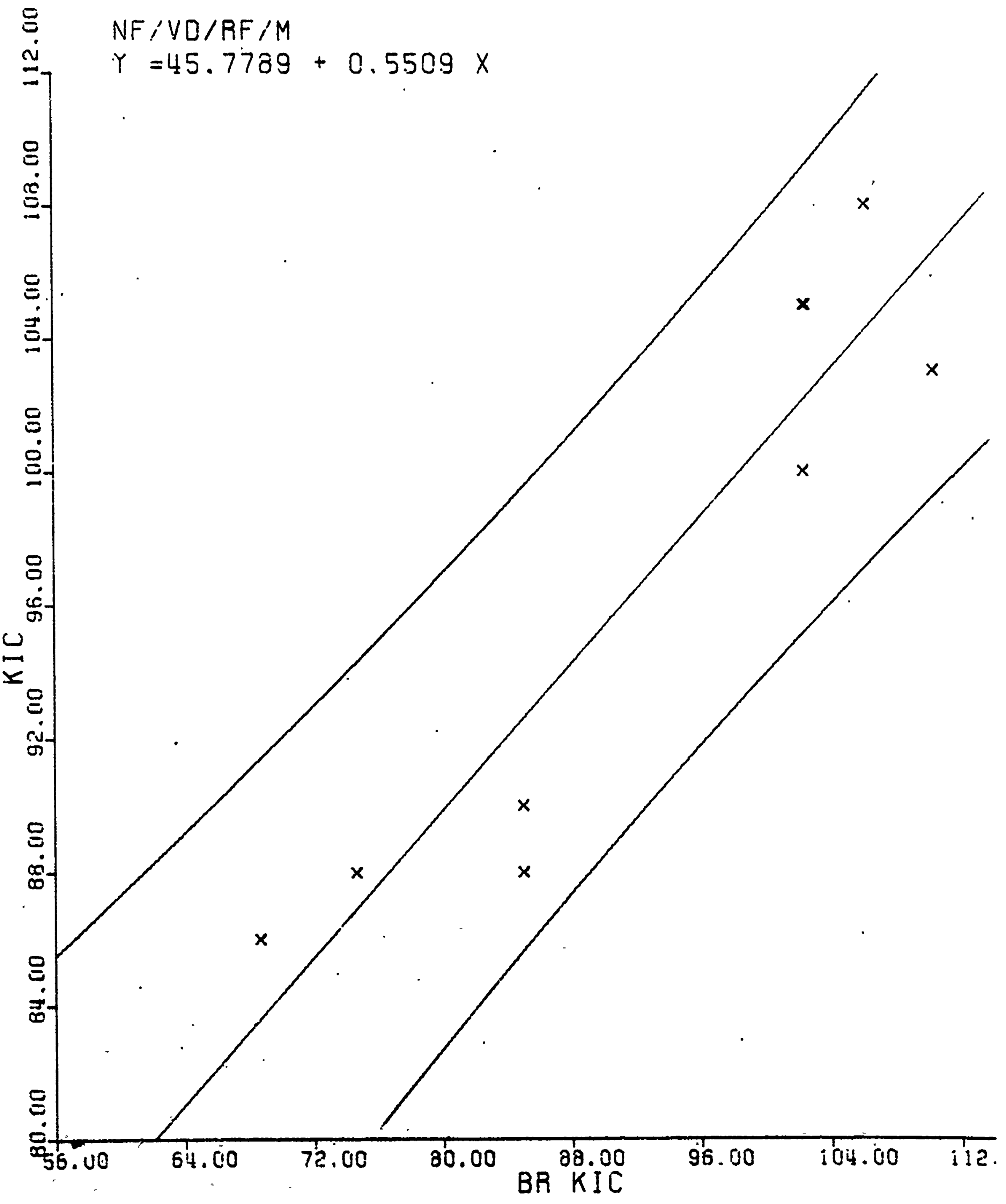


Fig. 10. REGRESSION OF B.R. K_{I_C} UPON K_{I_C} WITH 90% CONFIDENCE ENVELOPES; National Forge, Vacuum-Degassed, rotary forged, breech data.

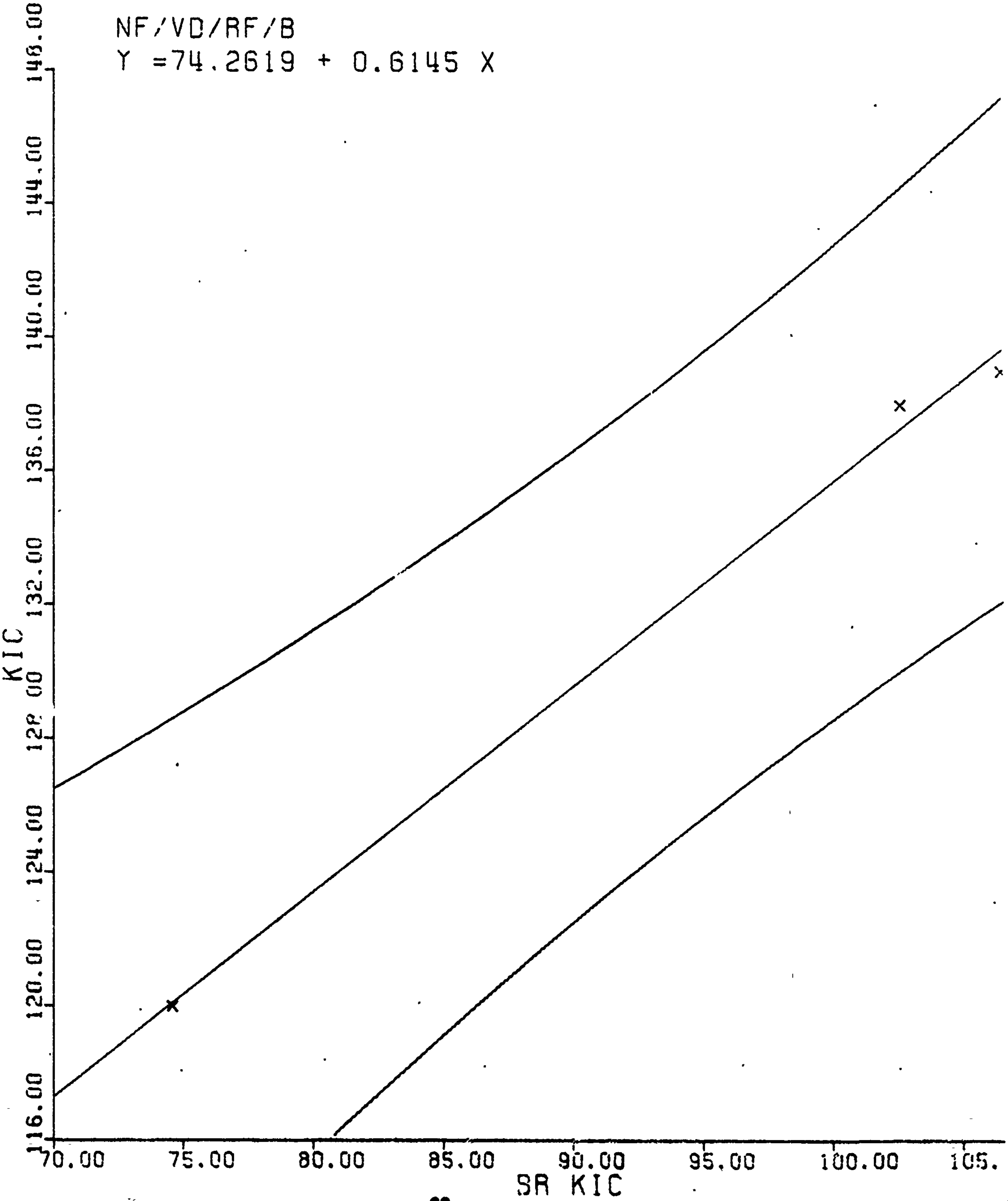


Fig. 11. REGRESSION OF B.R. K_{Ic} UPON K_{Ic} WITH 90% CONFIDENCE ENVELOPES; All muzzle data.

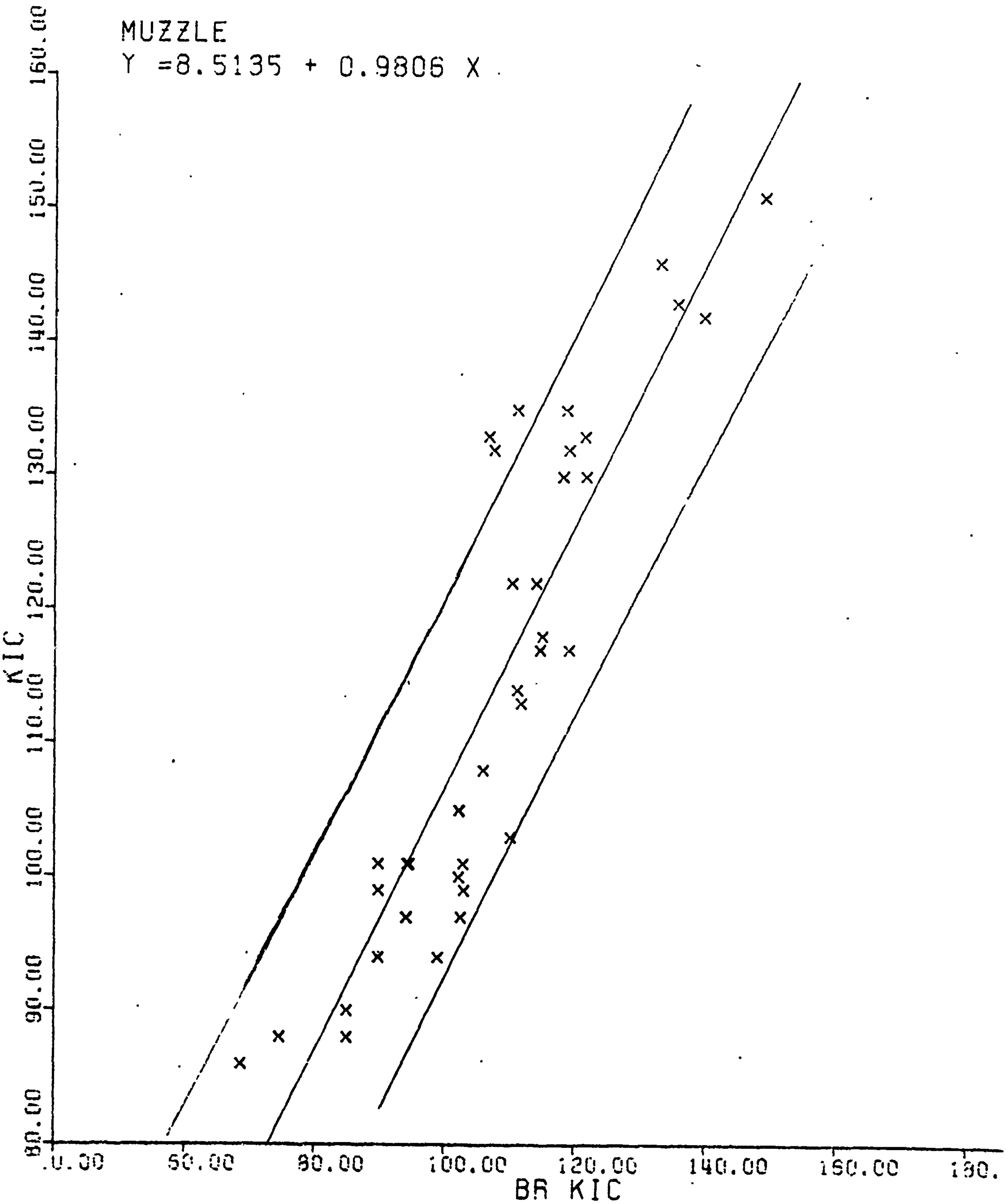


Fig. 12. REGRESSION OF B.R. K_{Ic} UPON K_{Ic} WITH 90% CONFIDENCE ENVELOPES; All breech data.

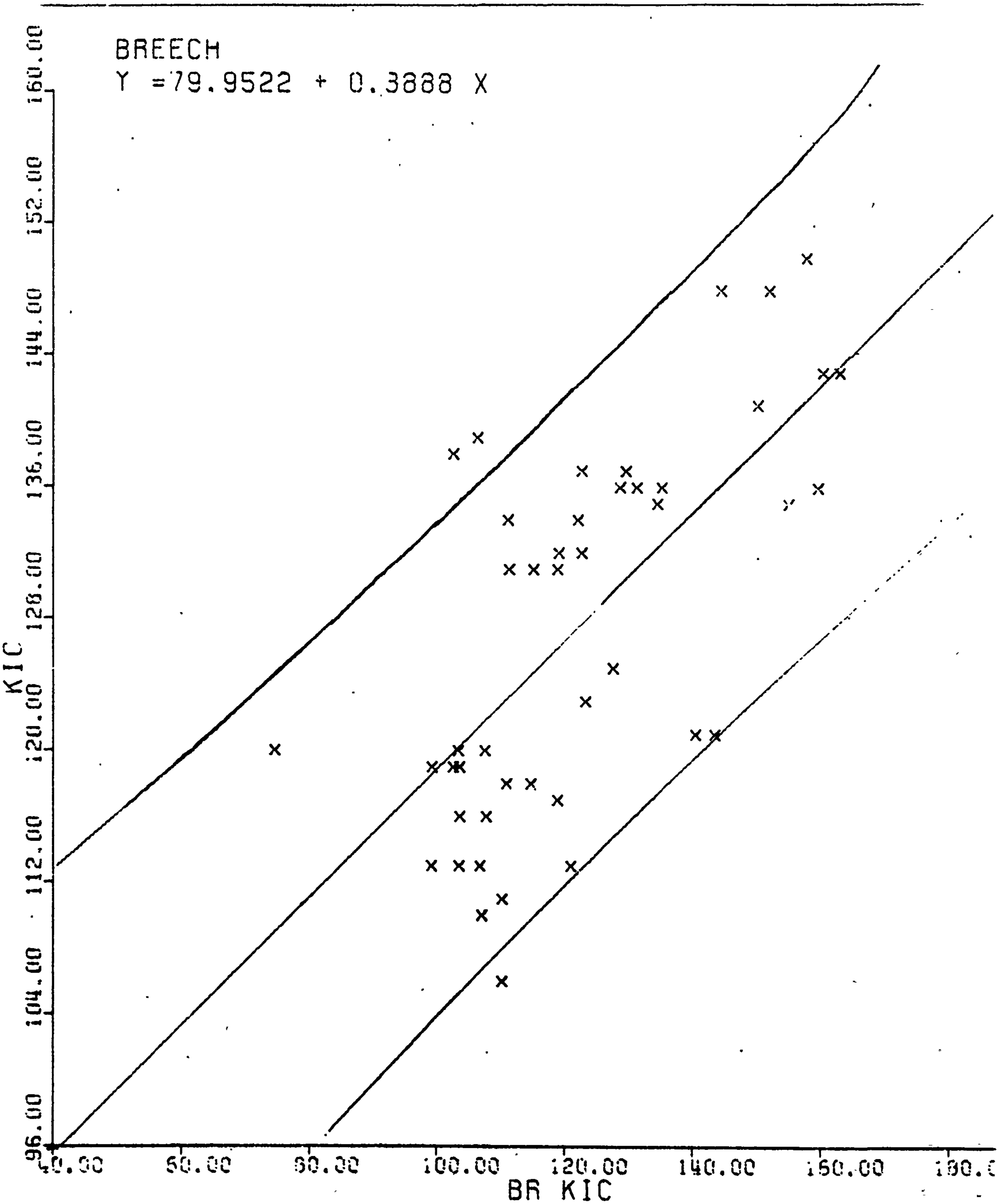
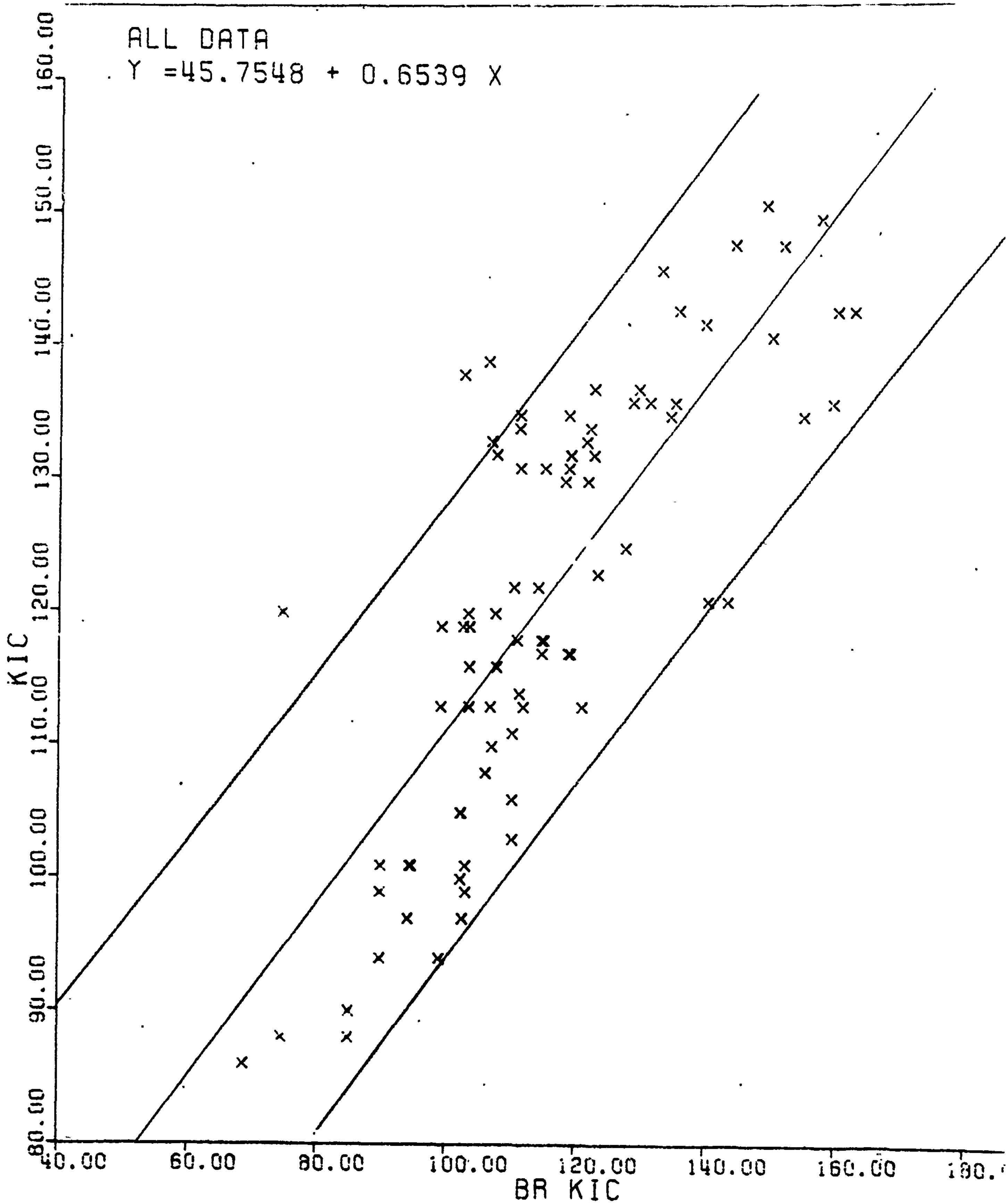


Fig. 13. REGRESSION OF B.R. K_{Ic} UPON K_{Ic} WITH 90% CONFIDENCE ENVELOPES; All data.



the equation to different data sets. By doing this you are, in effect, applying an equation to fit the data, not applying data to an equation which has a conceptual basis and which could be used for predictive purposes.

Model fitting and statistical tests are difficult to apply to mechanical property test results of material systems. You are measuring properties which are a function of many variables (e.g., chemical composition, refining process, thermomechanical processing, location of specimen within tube, etc.) and many of these are not independent and thus, interaction terms are present. Many of these variables are uncontrollable or unknown and thus, the measure of a particular quantity may have considerable scatter. Further, regression analysis assumes no error is involved in mechanical test measurement and this is not true. Thus, while statistics and model fitting are a powerful tool in addressing this type of problem, there is also the potential to misinterpret results.

For example, the Barsom-Rolfe correlation gives a reasonable correlation to predict K_{I_c} on the basis of tensile and Charpy V-notch data. The accuracy of the K_{I_c} correlation is analogous to the correlations among tensile strength, yield strength, % RA and hardness in martensitic steels. It may be used as a rough guide but not to predict a value within a few percents of its true value. As shown in Figures 4-13 this correlation cannot be used to confidently predict K_{I_c} more closely than $\pm$ 6 - 18% of the actual value, depending upon the data set. Even in these cases, the correlation may be expected to exceed the limits one out of ten times. For a critical application such as gun tubes this confidence level should be 99%, which would greatly expand the confidence envelopes.

A question to be asked now is, can improvements be made in this correlation or in developing another correlation? Improvements in the Barsom-Rolfe correlation might include improving data measurement, e.g., recalibrating equipment to reduce measurement error.

Developing a correlation based on ther mechanical property tests again requires comparing the K_{I_c} test specimen with other test specimens and test conditions. To reiterate, the principal variables in LEFM are temperature, loading rate, and by definition, the state of stress. The first two are usually controllable with any specimen type. The state of stress at the crack tip under Mode I deformation is primarily a function of notch acuity and specimen shape and size. Thus, a better correlation might be developed by fatigue precracking a Charpy specimen and slow bend testing it at room temperature. The measured value of W/A (energy absorbed per unit distance of crack extension measure in in.lb/in.) could conceivably be closely related to K_{I_c}.

Such a relation which has been explored with good results by Ronald et al[8] involves the theoretical equality between K_{I_c} and G_{I_c}, the critical strain energy release rate

$$K_{I_c}2 = \frac{G_{I_c}}{1-D^2}$$

Ronald assumed that $G_{I_c} = (W/A)$. Combining these equations results in the following relation between K_{I_c} and W/A

$$K_{I_c} = \frac{E}{1-\nu 2 \ (W/A)}$$

CONCLUSIONS/SUMMARY

1. The K_{I_c} fracture toughness test provides a superior measure of the resistance of a steel to fracture or fatigue failure than the Charpy V-notch test. It is more useful than the Charpy V-notch because the results can be related to design parameters. However, the test is expensive.

2. Of the correlations investigated between K_{I_c} and conventional mechanical property tests, the Barsom-Rolfe upper-shelf correlation provides the best correlation of K_{I_c} to Charpy V-notch.

3. The correlation coefficients of Barsom-Rolfe correlation did not agree with those presented in the literature.

4. The variance in the correlation limits the prediction of K_{I_c} for a particular steel to $\pm$ 6-18% of the true value.

5. Correlations utilizing other types of test specimens may be possible but would require extensive testing and evaluation.

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APPENDIX

CABOT ESR
ROTARY FORGED
105mm M68
BREECH

TUBE	Y.S.	R.A.	CVN (-40°F)	CVN (R.T.)	K_{IC}
0014B	172 ksi	46%	25 ft-lbs.	30 ft-lbs.	143 ksi in.
	171	44	26	31	131
0015B	175	34	28		126
	175	47	20		132
0024T	172	47	23	23	114
	172	42	22	24	120
0025B	172	52	30		135
	175	50	32		141
0028B	169	45	28		136
	170	44	26		137
0030TH	176	42	26	31	142
	176	47	27	32	140
0030B	172	41	25		134
	170	49	24		129
0033T	172	44	23	24	118
	174	45	22	25	119
0033B	175	35	24		129
	174	45	20		127
0035BH	171	46	28	30	136
	175	45	24	29	146
0038T	172	46	25		124
	170	49	26		122
0042B	170	43	22		128
	170	45	23		127
0051T	176	37	22	26	119
	175	45	22	25	117

CABOT ESR
ROTARY FORGED
105mm M68
BREECH
(Continued)

TUBE	Y.S.	R.A.	CVN (-40°F)	CVN (R.T.)	K_{IC}
0052T	170	45	23	27	120
	170	42	20	22	117
0053T	175	38	21	23	115
	177	41	18	23	113
0054T	174	47	24		129
	177	49	24		136
0055T	177	48	24	35	146
	176	52	27	36	143
0057T	178	41	20		124
	178	40	21		125
0058B	169	47	30	39	150
	167	46	28	38	151
0059T	167	46	27		131
	167	48	24		137

CABOT ESR
ROTARY FORGED
105mm M68
Muzzle

TUBE	Y.S.	R.A.	CVN (-40°F)	CVN (R.T.)	K_{IC}
0014BH	170 ksi	44%	28 ft-lbs.		127 ksi in.
	169	47	27		133
0015B	165	49	21		105
	167	45	27		128
0024T	170	46	22	22 ft-lbs.	110
	169	46	24	23	100
0025B	165	45	32		128
	165	47	32		123
0028B	160	47	27	28	123
	160	42	28	27	105
0030T	167	52	30	26	110
	167	51	30	29	136
0030B	167	43	26		129
	167	44	25		116
0033T	167	51	24	23	113
	166	50	24	22	101
0033B	165	49	27		116
	166	45	26		107
0035B	165	47	27	26	113
	164	48	30	26	119
0038T	166	46	25		121
	167	45	25		111
0042B	167	49	26		121
	165	52	25		121
0051T	165	46	24	23	111
	161	48	25	23	107

CABOT ESR
ROTARY FORGED
105mm M68
Muzzle
(Continued)

TUBE	Y.S.	R.A.	CVN (-40°F)	CVN (R.T.)	K_{IC}
0052B	165	45	22	20	119
	165	42	23	23	107
0053T	165	45	22	22	106
	167	47	22	24	101
0054T	166	49	29		110
	165	51	30		127
0055T	167	54	35	29	135
	167	54	33	31	129
0057T	171	44	21		104
	172	42	21		100
0058B	165	45	30	28	125
	168	45	32	29	129
0059T	158	49	28		119
	157	51	31		126

CABOT VD
ROTARY FORGED
105mm M68
BREECH

TUBE	Y.S.	R.A.	CVN (-40°F)	CVN (R.T.)	K_{I_C}
0662	172 ksi	42%	24 ft-lbs.	26 ft-lbs.	132 ksi in.
	171	38	22	23	134
0663	173	40	20		121
	171	42	21		120
0665	170	39	24	28	136
	170	41	24	30	126
0666	175	47	26	26	132
	174	46	23	28	137
0669	173	39	22	26	131
	174	38	21	25	132
0670	175	36	19		122
	175	36	18		121
0672	173	35	19	21	120
	176	37	19	22	117
0677	175	46	21		120
	174	36	19		122
0679	170	44	27	23	120
	170	45	21	24	118
0680	176	41	19	21	119
	176	38	19	20	119
0686	176	39	18		123
	175	36	18		122
0688	174	39	18	20	116
	175	31	18	21	113
0700	179	37	20	22	114
	174	29	16	21	120

CABOT VD
ROTARY FORGED
105mm M68
BREECH
(Continued)

TUBE	Y.S.	R.A.	CVN (-40°F)	CVN (R.T.)	K_{IC}
0703	170	40	25		126
	167	42	24		124
0705	174	37	23		126
	175	36	23		131
0709	170	42	22	23	126
	173	44	20	24	131
0713	169	46	20		125
	182	39	20		123
0716	176	42	23		121
	176	35	22		123
0718	170	42	22		123
	172	43	23		124
0720	174	34	21		128
	174	44	20		134

CABOT VD
ROTARY FORGED
105mm M68
MUZZLE

TUBE	Y.S.	R.A.	CVN (-40°F)	CVN (R.T.)	K_{I_C}
0662	168 ksi	43%	21 ft-lbs.	26 ft-lbs.	121
	168	44	20	22	133
0663	170	40	21	23	122
	172	39	20	25	135
0665	168	43	23		119
	167	38	23		119
0666	172	40	23	22	120
	175	40	21	25	132
0669	173	39	20		112
	171	35	20		105
0670	168	40	16	18	105
	170	39	17	21	99
0672	173	37	18	19	111
	169	34	17	21	101
0677	174	37	16	18	113
	173	38	16	20	94
0679	170	39	20		112
	171	33	18		111
0680	173	41	17		106
	173	35	16		112
0686	170	38	18		113
	171	43	18		102
0688	170	29	18	19	114
	165	34	17	21	97
0700	174	30	17	18	105
	172	32	18	19	101

CABOT VD
ROTARY FORGED
105mm M68
Muzzle
(Continued)

TUBE	Y.S.	R.A.	CVN (-40°F)	CVN (R.T.)	K_{I_C}
0703	174	39	20	23	112
	166	43	21	23	122
0705	171	45	22	25	122
	169	43	22	26	130
0709	168	37	22		119
	162	42	20		115
0713	168	32	19		106
	171	40	20		113
0716	171	40	19		118
	171	26	20		107
0718	172	41	21		104
	168	45	22		103
0720	170	37	22		114
	171	35	22		109

CABOT VD
CONVENTIONALLY FORGED
105mm M68
BREECH

TUBE	Y.S.	R.A.	CVN (-40°F)	CVN (R.T.)	K_{I_C}
6961	167ksi	53%	37 ft-lbs.		139 ksi in
	166	50	33		140
7067	170	50	32	33 ft-lbs.	148
	170	49	31	35	141
7126	168	51	36	39	143
	168	53	35	40	143
7135	170	48	29		129
	170	47	27		133
7156	172	42	19	22	120
	170	39	19	22	123
7222	173	43	21	25	131
	173	41	20	25	117
7223	170	49	28		142
	170	44	31		139
7225	168	51	31	38	150
	166	54	30	39	136
7234	168	49	32		134
	[illegible]	45	35		144
7235	165	47	28		137
	164	48	30		135
7238	167	39	26	33	121
	167	42	27	32	121
7242	164	51	35		145
	164	47	34		138
7243	167	47	31	36	148
	168	50	28	37	135

CABOT VD
CONVENTIONALLY FORGED
105mm M68
BREECH
(Continued)

TUBE	Y.S.	R.A.	CVN (-40°F)	CVN (R.T.)	K_{I_C}
7251	170	47	26		125
	169	43	27		127
7254	170	42	26		134
	170	43	33		132
7260	170	47	29		131
	168	49	29		136
7269	166	51	37		134
	167	51	36		143

NATIONAL FORGE VD
ROTARY FORGED
105mm M68
BREECH

TUBE	Y.S.	R.A.	CVN (-40°F)	CVN (R.T.)	K_{IC}
1693	166 ksi	39%	18 ft-lbs.		120 ksi in
	167	32	17		
1703	166	37	16		128
	167	40	17		
1734	166	37	19		126
	167	36	18		
1807	166	38	18		122
	166	41	17		
1810	166	44	21		128
	167	42	25		
1818	163	45	26		139
	165	44	23		
1822	162	41	19		124
	164	39	19		
1839	166	34	21		126
	167	38	19		
1842	165	41	19		140
	165	33	19		
1846	169	41	19		123
	167	39	17		
1847	165	42	20		138
	165	42	21		
1850	168	33	17		126
	168	42	18		
1851	165	25	17		112
	163	36	16		

NATIONAL FORGE VD
ROTARY FORGED
105mm M68
Breech
(Continued)

TUBE	Y.S.	R.A.	CVN (-40°F)	CVN (R.T.)	K_{IC}
1852	165	39	20		121
	165	32	19		
1865	166	36	21		128
	165	41	19		
1875	165	38	21		131
	167	41	20		
1931	167	43	22		134
	167	36	21		
1943	170	35	18		122
	169	32	16		
2004	165	35	18		114
	164	38	18		
2005	168	37	18		124
	167	37	18		

NATIONAL FORGE VD
ROTARY FORGED
105mm M68
Muzzle

TUBE	Y.S.	R.A.	CVN (-40°F)	CVN (R.T.)	K_{I_C}
1693	167 ksi	39%	17 ft-lbs.	18 ft-lbs.	90 ski in
	167	39	17	15	
1703	166	43	16		100
	166	40	18		
1734	165	37	16		100
	166	38	16		
1807	168	38	16	16	88
	169	36	15	14	86
1810	165	43	17		100
	165	41	17		100
1818	161	43	18	23	99
	162	44	19	21	108
1822	162	42	17		97
	162	43	17		92
1839	166	42	17	23	103
	165	43	17	18	95
1842	165	41	17		99
	165	35	17		98
1846	168	40	17		94
	168	42	17		105
1847	162	42	19	22	97
	163	44	18	20	100
1850	168	38	13		91
	168	38	14		95
1851	165	30	14	16	95
	165	35	15	14	88
1852	165	36	15	14	86
	165	30	13	13	85

NATIONAL FORGE VD
ROTARY FORGED
105mm M68
Muzzle
(Continued)

TUBE	Y.S.	R.A.	CVN (-40°F)	CVN (R.T.)	K_{I_C}
1865	163	41	17		99
	163	39	18		
1875	165	44	18	24	98
	164	41	19	20	105
1931	163	45	18	21	98
	163	36	18	20	105
1943	168	33	14	18	89
	168	34	13	16	88
2004	162	31	17		99
	162	34	16		97
2005	164	36	17		97
	163	39	16		96

CABOT ESR
ROTARY FORGED
155mm M185
BREECH

TUBE	Y.S.	R.A.	CVN (-40°F)	CVN (R.T.)	K_{IC}
455-1R	174 ksi	51%	30 ft-lbs.		147 ksi in.
	172	52	25	35	156
461-2R	169	46	29		139
	170	47	31	32	138
461-5R	172	51	29	33	138
	172	51	29		141
461-3R	173	48	29		143
	172	51	28		142
608-5R	173	51	28	34	151
	174	56	26		145

C/ESR/RF/M

COEF.B(I)	S.E. COEF.	LOWER	UPPER
-.87013E 01	0.13914E 02	-.35063E 02	0.17660E 02
0.10967E 01	0.48199E 00	0.18354E 00	0.20099E 01

MEAN	VARIANCE	ST.DEV.	
0.12556E 03	0.19684E 03	0.14030E 02	BR KIC
0.12900E 03	0.25350E 03	0.15922E 02	KIC

F-VALUE 99.
RES. RMS 4.373432
NO. OF OBS. 9
CORR. COEF. SQRD .934

OBS.	X	OBS. Y	PREDICTED Y	LOWER	UPPER	RESIDUAL
1	0.1113E 03	0.114 E 03	0.1133E 03	0.1041E 03	0.1226E 03	0.6541E 00
2	0.1119E 03	0.113 E 03	0.1140E 03	0.1048E 03	0.1232E 03	-0.1028E 01
3	0.1148E 03	0.117 E 03	0.1172E 03	0.1082E 03	0.1262E 03	-0.1833E 00
4	0.1151E 03	0.118 E 03	0.1175E 03	0.1085E 03	0.1265E 03	0.4875E 00
5	0.1192E 03	0.117 E 03	0.1221E 03	0.1132E 03	0.1309E 03	-0.5075E 01
6	0.1331E 03	0.146 E 03	0.1373E 03	0.1284E 03	0.1462E 03	0.8714E 01
7	0.1357E 03	0.143 E 03	0.1401E 03	0.1311E 03	0.1491E 03	0.2918E 01
8	0.1398E 03	0.142 E 03	0.1446E 03	0.1354E 03	0.1538E 03	-0.2589E 01
9	0.1492E 03	0.151 E 03	0.1549E 03	0.1449E 03	0.1649E 03	-0.3901E 01

XMAX = 0.14917E 03 XMIN = 0.11128E 03

YMAX = 0.15100E 03 YMIN = 0.11300E 03

C/ESR/RF/B

COEF.B(I)	S.E. COEF.	LOWER	UPPER
0.31448E 02	0.22021E 02	-.95027E 01	0.72396E 02
0.74612E 00	0.11951E 01	-.14761E 01	0.29683E 01

MEAN	VARIANCE	ST.DEV.	
0.11748E 03	0.13073E 03	0.11434E 02	BR KIC
0.11910E 03	0.10921E 03	0.1 450E 02	KIC

F-VALUE 16.0
RES. RMS 6.402452
NO. OF OBS. 10
CORR. COEF. SQRD 0.6664

OBS.	X	OBS. Y	PREDICTED Y	LOWER	UPPER	RESIDUAL
1	0.1026E 03	0.1190E 03	0.1080E 03	0.9445E 02	0.1215E 03	0.1103E 02
2	0.1068E 03	0.113 E 03	0.1111E 03	0.9807E 02	0.1241E 03	0.1897E 01
3	0.1071E 03	0.110 E 03	0.1114E 03	0.9838E 02	0.1244E 03	-0.1373E 01
4	0.1103E 03	0.1110E 03	0.1138E 03	0.1010E 03	0.1265E 03	-0.2754E 01
5	0.1103E 03	0.1060E 03	0.1138E 03	0.1010E 03	0.1265E 03	-0.7754E 01
6	0.1210E 03	0.113 E 03	0.1217E 03	0.1092E 03	0.1343E 03	-0.8736E 01
7	0.1233E 03	0.1230E 03	0.1234E 03	0.1108E 03	0.1361E 03	-0.4353E 00
8	0.1276E 03	0.1250E 03	0.1267E 03	0.1137E 03	0.1397E 03	-0.1687E 01
9	0.1313E 03	0.1360E 03	0.1294E 03	0.1160E 03	0.1428E 03	0.6578E 01
10	0.1345E 03	0.135 E 03	0.1318E 03	0.1180E 03	0.1456E 03	0.3234E 01

XMAX = 0.13445E 03 XMIN = 0.10256E 03

YMAX = 0.13600E 03 YMIN = 0.10600E 03

C/VD/RF/M

COEF.B(I)	S.E. COEF.	LOWER	UPPER
-.23105E 02	0.19270E 02	-.56522E 02	0.10311E 02
0.13030E 01	0.16006E 01	-.14726E 01	0.40785E 01

MEAN	VARIANCE	ST.DEV.	
0.10553E 03	0.12386E 03	0.11129E 02	BR KIC
0.11440E 03	0.28383E 03	0.16847E 02	KIC

F-VALUE	51.5
RES. RMS	8.811608
NO. OF OBS.	20
CORR. COEF. SQRD	0.7409

OBS.	X	OBS. Y	PREDICTED Y	LOWER	UPPER	RESIDUAL
1	0.8986E 02	0.9900E 02	0.9398E 02	0.7756E 02	0.1104E 03	0.5019E 01
2	0.8991E 02	0.1010E 03	0.9405E 02	0.7763E 02	0.1105E 03	0.6954E 01
3	0.8993E 02	0.9400E 02	0.9407E 02	0.7766E 02	0.1105E 03	-0.7310E-01
4	0.9417E 02	0.9700E 02	0.9960E 02	0.8354E 02	0.1157E 03	-0.2600E 01
5	0.9442E 02	0.1010E 03	0.9992E 02	0.8387E 02	0.1160E 03	0.1082E 01
6	0.9457E 02	0.1010E 03	0.1001E 03	0.8409E 02	0.1162E 03	0.8801E 00
7	0.9908E 02	0.9400E 02	0.1060E 03	0.9021E 02	0.1218E 03	-0.1200E 02
8	0.1026E 03	0.9700E 02	0.1105E 03	0.9484E 02	0.1262E 03	-0.1353E 02
9	0.1030E 03	0.1010E 03	0.1111E 03	0.9540E 02	0.1268E 03	-0.1007E 02
10	0.1031E 03	0.9900E 02	0.1112E 03	0.9552E 02	0.1269E 03	-0.1220E 02
11	0.1069E 03	0.1330E 03	0.1162E 03	0.1005E 03	0.1318E 03	0.1684E 02
12	0.1077E 03	0.1320E 03	0.1172E 03	0.1015E 03	0.1329E 03	0.1481E 02
13	0.1105E 03	0.1220E 03	0.1208E 03	0.1051E 03	0.1366E 03	0.1182E 01
14	0.1113E 03	0.1350E 03	0.1219E 03	0.1061E 03	0.1377E 03	0.1311E 02
15	0.1142E 03	0.1220E 03	0.1256E 03	0.1097E 03	0.1415E 03	-0.3633E 01
16	0.1183E 03	0.1300E 03	0.1310E 03	0.1148E 03	0.1471E 03	-0.9799E 00
17	0.1188E 03	0.1350E 03	0.1316E 03	0.1154E 03	0.1478E 03	0.3565E 01
18	0.1192E 03	0.1320E 03	0.1323E 03	0.1160E 03	0.1485E 03	-0.2637E 00
19	0.1216E 03	0.1330E 03	0.1353E 03	0.1189E 03	0.1518E 03	-0.2322E 01
20	0.1218E 03	0.1300E 03	0.1356E 03	0.1191E 03	0.1520E 03	-0.5567E 01

XMAX = 0.12178E 03 XMIN = 0.89861E 02

YMAX = 0.13500E 03 YMIN = 0.94000E 02

C/VD/RF/B

COEF.B(I)	S.E. COEF.	LOWER	UPPER
0.43835E 02	0.11989E 02	0.23045E 02	0.64625E 02
0.71984E 00	0.50953E 00	-.16374E 00	0.16034E 01

MEAN	VARIANCE	ST.DEV.	
0.11359E 03	0.11192E 03	0.10579E 02	BR KIC
0.12560E 03	0.80253E 02	0.89584E 01	KIC

F-VALUE	46.9
RES. RMS	4.847296
NO. OF OBS.	20
CORR. COEF. SQRD	0.7226

OBS.	X	OBS. Y	PREDICTED Y	LOWER	UPPER	RESIDUAL
1	0.9922E 02	0.1130E 03	0.1153E 03	0.1063E 03	0.1243E 03	-0.2255E 01
2	0.9928E 02	0.1190E 03	0.1153E 03	0.1063E 03	0.1243E 03	0.3701E 01
3	0.1034E 03	0.1200E 03	0.1183E 03	0.1095E 03	0.1271E 03	0.1700E 01
4	0.1035E 03	0.1130E 03	0.1184E 03	0.1096E 03	0.1272E 03	-0.5361E 01
5	0.1036E 03	0.1160E 03	0.1184E 03	0.1096E 03	0.1272E 03	-0.2421E 01
6	0.1036E 03	0.1190E 03	0.1184E 03	0.1096E 03	0.1272E 03	0.5786E 00
7	0.1076E 03	0.1200E 03	0.1213E 03	0.1126E 03	0.1300E 03	-0.1268E 01
8	0.1078E 03	0.1160E 03	0.1214E 03	0.1127E 03	0.1301E 03	-0.5418E 01
9	0.1110E 03	0.1180E 03	0.1238E 03	0.1151E 03	0.1324E 03	-0.5751E 01
10	0.1112E 03	0.1340E 03	0.1238E 03	0.1152E 03	0.1325E 03	0.1015E 02
11	0.1114E 03	0.1310E 03	0.1240E 03	0.1154E 03	0.1327E 03	0.6965E 01
12	0.1148E 03	0.1180E 03	0.1265E 03	0.1178E 03	0.1351E 03	-0.8460E 01
13	0.1152E 03	0.1310E 03	0.1268E 03	0.1182E 03	0.1354E 03	0.4218E 01
14	0.1191E 03	0.1320E 03	0.1296E 03	0.1209E 03	0.1382E 03	0.2443E 01
15	0.1221E 03	0.1340E 03	0.1318E 03	0.1230E 03	0.1405E 03	0.2239E 01
16	0.1227E 03	0.1320E 03	0.1321E 03	0.1234E 03	0.1409E 03	-0.1473E 00
17	0.1227E 03	0.1370E 03	0.1321E 03	0.1234E 03	0.1409E 03	0.4853E 01
18	0.1287E 03	0.1360E 03	0.1365E 03	0.1275E 03	0.1456E 03	-0.5105E 00
19	0.1296E 03	0.1370E 03	0.1371E 03	0.1280E 03	0.1462E 03	-0.1124E 00
20	0.1352E 03	0.1360E 03	0.1411E 03	0.1317E 03	0.1506E 03	-0.5147E 01

XMAX = 0.13519E 03 XMIN = 0.99216E 02

YMAX = 0.13700E 03 YMIN = 0.11300E 03

C/VD/CF/B

COEF.E(I)	S.E. COEF.	LOWER	UPPER
0.63139E 02	0.27412E 02	0.13455E 02	0.11282E 03
0.49686E 00	0.17024E 01	-.25888E 01	0.35825E 01

ME	VARIANCE	ST.DEV.	
0.14698E 03	0.22189E 03	0.14896E 02	BR KIC
0.13617E 03	0.13124E 03	0.11456E 02	KIC

F-VALUE	7.2
RES. RMS	9.171 80
NO. OF OBS.	12
CORR. COEF. SQRD	0.4174

OBS.	X	OBS. Y	PREDICTED Y	LOWER	UPPER	RESIDUAL
1	0.1189E 03	0.131 E 03	0.1222E 03	0.1025E 03	0.1419E 03	0.8773E 01
2	0.1189E 03	0.117 E 03	0.1222E 03	0.1025E 03	0.1419E 03	-0.5227E 01
3	0.1405E 03	0.121 E 03	0.1330E 03	0.1155E 03	0.1504E 03	-0.1196E 02
4	0.1435E 03	0.121 E 03	0.1344E 03	0.1171E 03	0.1518E 03	-0.1342E 02
5	0.1443E 03	0.148 E 03	0.1348E 03	0.1175E 03	0.1522E 03	0.1316E 02
6	0.1501E 03	0.141 E 03	0.1377E 03	0.1204E 03	0.1550E 03	0.3290E 01
7	0.1519E 03	0.148 E 03	0.1386E 03	0.1213E 03	0.1565E 03	0.9365E 01
8	0.1550E 03	0.135 E 03	0.1402E 03	0.1226E 03	0.1577E 03	-0.5151E 01
9	0.1577E 03	0.15 E 03	0.1415E 03	0.1238E 03	0.1592E 03	0.8514E 01
10	0.1596E 03	0.136 E 03	0.1425E 03	0.1246E 03	0.1603E 03	-0.6452E 01
11	0.1603E 03	0.143 E 03	0.1428E 03	0.1249E 03	0.1607E 03	0.2017E 00
12	0.1629E 03	0.143 E 03	0.1441E 03	0.1260E 03	0.1622E 03	-0.1089E 01

XMAX = 0.16292E 03 XMIN = 0.11892E 03

YMAX = 0.15000E 03 YMIN = 0.11700E 03

NF/VD/RF/M

COEF.B(I)	S.E. COEF.	LOWER	UPPER
0.45779E 02	0.76075E 01	0.31366E 02	0.60192E 02
0.55087E 00	0.27702E 00	0.26033E-01	0.10757E 01

MEAN	VARIANCE	ST.DEV.	
0.92981E 02	0.22404E 03	0.14968E 02	BR KIC
0.97000E 02	0.78250E 02	0.88459E 01	KIC

F-VALUE	46.4
RES. RMS	3.4246 01
NO. OF OBS.	9
CORR. COEF. SQRD	0.8689

OBS.	X	OBS. Y	PREDICTED Y	LOWER	UPPER	RESIDUAL
1	0.6869E 02	0.8600E 02	0.8362E 02	0.7583E 02	0.9140E 02	0.2384E 01
2	0.7462E 02	0.8800E 02	0.8689E 02	0.7949E 02	0.9428E 02	0.1113E 01
3	0.8499E 02	0.9000E 02	0.9260E 02	0.8565E 02	0.9954E 02	-0.2596E 01
4	0.8499E 02	0.8800E 02	0.9260E 02	0.8565E 02	0.9955E 02	-0.4600E 01
5	0.1023E 03	0.1000E 03	0.1022E 03	0.9517E 02	0.1091E 03	-0.2153E 01
6	0.1023E 03	0.1050E 03	0.1022E 03	0.9517E 02	0.1091E 03	0.2847E 01
7	0.1024E 03	0.1050E 03	0.1022E 03	0.9522E 02	0.1092E 03	0.2784E 01
8	0.1061E 03	0.1080E 03	0.1042E 03	0.9710E 02	0.1114E 03	0.3769E 01
9	0.1103E 03	0.1030E 03	0.1065E 03	0.9921E 02	0.1139E 03	-0.3547E 01

XMAX = 0.11031E 03 XMIN = 0.68686E 02

YMAX = 0.10800E 03 YMIN = 0.86000E 02

NF/VC/RF/B

COEF.B(I)	S.E. COEF.	LOWER	UPPER
0.74262E 02	0.37227E 01	0.51758E 02	0.97766E 02
0.61449E 00	0.37271E-01	0.37917E 00	0.84981E 00

MEAN	VARIANCE	ST.DEV.	
0.94513E 02	0.30158E 03	0.17366E 02	BR KIC
0.13233E 03	0.11433E 03	0.10693E 02	KIC

F-VALUE 248.8
RES. RMS 0.956736
NO. OF OBS. 3
CORR. COEF. SQRD 0.996

OBS.	X	OBS. Y	PREDICTED Y	LOWER	UPPER	RESIDUAL
1	0.7457E 02	0.1200E 03	0.1201E 03	0.1116E 03	0.1286E 03	-0.8582E-01
2	0.1026E 03	0.138 E 03	0.1373E 03	0.1300E 03	0.1445E 03	0.7153E 00
3	0.1064E 03	0.139 E 03	0.1396E 03	0.1321E 03	0.1472E 03	-0.6295E 00

XMAX = 0.10638E 03 XMIN = 0.74572E 02

YMAX = 0.13900E 03 YMIN = 0.12000E 03

MUZZLE

COEF.B(I)	S.E. COEF.	LOWER	UPPER
0.85135E 01	0.86962E 01	-.61683E 01	0.23195E 02
0.98062E 00	0.66106E 00	-.13544E 00	0.20967E 01

MEAN	VARIANCE	ST.DEV.	
0.10730E 03	0.28724E 03	0.16948E 02	BR KIC
0.11374E 03	0.34252E 03	0.18507E 02	KIC

F-VALUE 150.
RES. RMS 8.255245
NO. OF OBS. 38
CORR. COEF. SQRD 0.8[illegible]64

OBS.	X	OBS. Y	PREDICTED Y	LOWER	UPPER	RESIDUAL
1	0.6869E 02	0.86[illegible]E 02	0.7587E 02	0.6081E 02	0.9892E 02	0.1013E 02
2	0.7462E 02	0.88[illegible]E 02	0.8169E 02	0.6690E 02	0.9649E 02	0.6308E 01
3	0.8499E 02	0.9[illegible]E 02	0.9185E 02	0.7742E 02	0.1063E 03	-0.1854E 01
4	0.8499E 02	0.880 E 02	0.9186E 02	0.7742E 02	0.1063E 03	-0.3061E 01
5	0.8986E 02	0.990 E 02	0.9663E 02	0.8232E 02	0.1109E 03	0.2367E 01
6	0.8991E 02	0.101 E 03	0.9668E 02	0.8237E 02	0.1110E 03	0.4318E 01
7	0.8993E 02	0.94[illegible]E 02	0.9670E 02	0.8239E 02	0.1110E 03	-0.2703E 01
8	0.9417E 02	0.97[illegible]E 02	0.1009E 03	0.8663E 02	0.1151E 03	-0.3863E 01
9	0.9442E 02	0.1[illegible]1 E 03	0.1011E 03	0.8688E 02	0.1153E 03	-0.1020E 00
10	0.9457E 02	0.101[illegible]E 03	0.1013E 03	0.8703E 02	0.1155E 03	-0.2538E 00
11	0.9908E 02	0.940 E 02	0.1057E 03	0.9151E 02	0.1198E 03	-0.1168E 02
12	0.1023E 03	0.1[illegible]5 E 03	0.1089E 03	0.9473E 02	0.1230E 03	-0.3867E 01
13	0.1023E 03	0.1[illegible] E 03	0.1089E 03	0.9473E 02	0.1230E 03	-0.8867E 01
14	0.1024E 03	0.1[illegible]5 E 03	0.1[illegible]90E 03	0.9484E 02	0.1231E 03	-0.3978E 01
15	0.1026E 03	0.97[illegible] E 02	0.1091E 03	0.9495E 02	0.1232E 03	-0.1209E 02
16	0.1030E 03	0.101[illegible]E 03	0.1095E 03	0.9537E 02	0.1236E 03	-0.8498E 01
17	0.1031E 03	0.99[illegible]E 02	0.1096E 03	0.9546E 02	0.1237E 03	-0.1059E 02
18	0.1061E 03	0.1[illegible]8 E 03	0.1126E 03	0.9845E 02	0.1267E 03	-0.4566E 01
19	0.1069E 03	0.133 E 03	0.1133E 03	0.9921E 02	0.1274E 03	0.1967E 02
20	0.1077E 03	0.132[illegible]E 03	0.1141E 03	0.9998E 02	0.1282E 03	0.1790E 02
21	0.1103E 03	0.1[illegible]3 E 03	0.1167E 03	0.1026E 03	0.1308E 03	-0.1369E 02
22	0.1105E 03	0.122 E 03	0.1168E 03	0.1027E 03	0.1310E 03	0.5169E 01
23	0.1113E 03	0.114 E 03	0.1176E 03	0.1035E 03	0.1318E 03	-0.3641E 01
24	0.1113E 03	0.135 E 03	0.1176E 03	0.1035E 03	0.1318E 03	0.1736E 02
25	0.1119E 03	0.113[illegible]E 03	0.1183E 03	0.1041E 03	0.1324E 03	-0.5250E 01
26	0.1142E 03	0.122[illegible]E 03	0.12[illegible]5E 03	0.1063E 03	0.1346E 03	0.1545E 01
27	0.1148E 03	0.117[illegible]E 03	0.1211E 03	0.1069E 03	0.1352E 03	-0.4072E 01
28	0.1151E 03	0.118[illegible]E 03	0.1214E 03	0.1072E 03	0.1355E 03	-0.3366E 01
29	0.1183E 03	0.130[illegible]E 03	0.1245E 03	0.1103E 03	0.1387E 03	0.5521E 01
30	0.1188E 03	0.135[illegible]E 03	0.1250E 03	0.1108E 03	0.1392E 03	0.1003E 02
31	0.1192E 03	0.132[illegible]E 03	0.1254E 03	0.1112E 03	0.1397E 03	0.6555E 01
32	0.1192E 03	0.117[illegible]E 03	0.1254E 03	0.1112E 03	0.1397E 03	-0.8445E 01
33	0.1216E 03	0.133[illegible]E 03	0.1277E 03	0.1135E 03	0.1420E 03	0.5253E 01
34	0.1218E 03	0.130[illegible]E 03	0.1279E 03	0.1137E 03	0.1422E 03	0.2069E 01
35	0.1331E 03	0.146 E 03	0.1390E 03	0.1245E 03	0.1536E 03	0.6954E 01
36	0.1357E 03	0.143[illegible]E 03	0.1415E 03	0.1269E 03	0.1562E 03	0.1454E 01
37	0.1398E 03	0.142[illegible]E 03	0.1456E 03	0.1308E 03	0.1604E 03	-0.3576E 01
38	0.1492E 03	0.151[illegible]E 03	0.1548E 03	0.1396E 03	0.1700E 03	-0.3797E 01

XMAX = 0.14917E 03 XMIN = 0.68686E 02
.151

BREECH

COEF.B(I)	S.E. COEF.	LOWER	UPPER
0.79952E 02	0.80770E 01	0.66374E 02	0.93530E 02
0.38883E 00	0.56769E 00	-.56551E 00	0.13432E 01

MEAN	VARIANCE	ST.DEV.	
0.12208E 03	0.40276E 03	0.20069E 02	BR KIC
0.12742E 03	0.13475E 03	0.11608E 02	KIC

F-VALUE 35.5
RES. RMS 3.693221
NO. OF OBS. 45
CORR. COEF. SQRD 0.4519

OBS.	X	OBS. Y	PREDICTED Y	LOWER	UPPER	RESIDUAL
1	0.7457E 02	0.1200E 03	0.1089E 03	0.9328E 02	0.1246E 03	0.1105E 02
2	0.9922E 02	0.1130E 03	0.1185E 03	0.1035E 03	0.1335E 03	-0.5531E 01
3	0.9928E 02	0.1190E 03	0.1186E 03	0.1036E 03	0.1335E 03	0.4454E 00
4	0.1026E 03	0.1380E 03	0.1198E 03	0.1049E 03	0.1348E 03	0.1817E 02
5	0.1026E 03	0.1190E 03	0.1198E 03	0.1049E 03	0.1348E 03	-0.8314E 00
6	0.1034E 03	0.1200E 03	0.1202E 03	0.1053E 03	0.1351E 03	-0.1754E 00
7	0.1035E 03	0.1130E 03	0.1202E 03	0.1053E 03	0.1351E 03	-0.7209E 01
8	0.1036E 03	0.1160E 03	0.1202E 03	0.1053E 03	0.1352E 03	-0.4241E 01
9	0.1036E 03	0.1190E 03	0.1202E 03	0.1053E 03	0.1352E 03	-0.1241E 01
10	0.1064E 03	0.1390E 03	0.1213E 03	0.1064E 03	0.1362E 03	0.1768E 02
11	0.1068E 03	0.1130E 03	0.1215E 03	0.1066E 03	0.1363E 03	-0.8464E 01
12	0.1071E 03	0.1100E 03	0.1216E 03	0.1067E 03	0.1365E 03	-0.1160E 02
13	0.1076E 03	0.1200E 03	0.1218E 03	0.1069E 03	0.1366E 03	-0.1779E 01
14	0.1078E 03	0.116 E 03	0.1219E 03	0.1070E 03	0.1367E 03	-0.5860E 01
15	0.1103E 03	0.1110E 03	0.1228E 03	0.1080E 03	0.1377E 03	-0.1185E 02
16	0.1103E 03	0.1060E 03	0.1228E 03	0.1080E 03	0.1377E 03	-0.1685E 02
17	0.1110E 03	0.1180E 03	0.1231E 03	0.1083E 03	0.1379E 03	-0.5120E 01
18	0.1112E 03	0.1340E 03	0.1232E 03	0.1083E 03	0.1380E 03	0.1083E 02
19	0.1114E 03	0.1310E 03	0.1233E 03	0.1085E 03	0.1381E 03	0.7727E 01
20	0.1148E 03	0.118 E 03	0.1246E 03	0.1098E 03	0.1394E 03	-0.6583E 01
21	0.1152E 03	0.1310E 03	0.1248E 03	0.1100E 03	0.1396E 03	0.6243E 01
22	0.1189E 03	0.1170E 03	0.1262E 03	0.1114E 03	0.1410E 03	-0.9194E 01
23	0.1189E 03	0.1310E 03	0.1262E 03	0.1114E 03	0.1410E 03	0.4806E 01
24	0.1191E 03	0.1320E 03	0.1263E 03	0.1115E 03	0.1410E 03	0.5744E 01
25	0.1210E 03	0.113 E 03	0.1270E 03	0.1122E 03	0.1418E 03	-0.1401E 02
26	0.1221E 03	0.1340E 03	0.1274E 03	0.1127E 03	0.1422E 03	0.6553E 01
27	0.1227E 03	0.1320E 03	0.1277E 03	0.1129E 03	0.1424E 03	0.4345E 01
28	0.1227E 03	0.1370E 03	0.1277E 03	0.1129E 03	0.1424E 03	0.9345E 01
29	0.1233E 03	0.1230E 03	0.1279E 03	0.1131E 03	0.1427E 03	-0.4891E 01
30	0.1276E 03	0.125 E 03	0.1296E 03	0.1148E 03	0.1444E 03	-0.4586E 01
31	0.1287E 03	0.1360E 03	0.1300E 03	0.1152E 03	0.1448E 03	0.5988E 01
32	0.1296E 03	0.1370E 03	0.1303E 03	0.1155E 03	0.1451E 03	0.6663E 01
33	0.1313E 03	0.136 E 03	0.1310E 03	0.1162E 03	0.1458E 03	0.4989E 01
34	0.1345E 03	0.1350E 03	0.1322E 03	0.1174E 03	0.1471E 03	0.2768E 01
35	0.1352E 03	0.136 E 03	0.1325E 03	0.1177E 03	0.1474E 03	0.3483E 01
36	0.1405E 03	0.121 E 03	0.1346E 03	0.1197E 03	0.1495E 03	-0.1359E 02
37	0.1435E 03	0.1210E 03	0.1357E 03	0.1208E 03	0.1507E 03	-0.1474E 02
38	0.1443E 03	0.1480E 03	0.1361E 03	0.1211E 03	0.1510E 03	0.1194E 02
39	0.1501E 03	0.1410E 03	0.1383E 03	0.1232E 03	0.1534E 03	0.2690E 01
40	0.1519E 03	0.148 E 03	0.1390E 03	0.1239E 03	0.1542E 03	0.8966E 01
41	[illegible]	[illegible]	[illegible]	[illegible]	0.1554E 03	-0.5230E 01
42	0.1577E 03	0.1500E 03	0.1413E 03	0.1260E 03	0.1565E 03	0.8735E 01
43	0.1596E 03	0.136 E 03	0.1420E 03	0.1267E 03	0.1574E 03	-0.6021E 01
44	0.1603E 03	0.143 E 03	0.1423E 03	0.1269E 03	0.1577E 03	0.7081E 00
45	0.1629E 03	0.1430E 03	0.1433E 03	0.1279E 03	0.1587E 03	-0.3023E 00

XMAX = 0.16292E 03 XMIN = 0.74572E 02

YMAX = 0.15000E 03 YMIN = 0.10600E 03

ALL DATA

COEF.B(I)	S.E. COEF.	LOWER	UPPER
0.45755E 02	0.65809E 01	0.34805E 02	0.56705E 02
0.65387E 00	0.57322E 00	-.29991E 00	0.16077E 01

MEAN	VARIANCE	ST.DEV.	
0.11532E 03	0.40062E 03	0.20015E 02	BP KIC
0.12116E 03	0.27391E 03	0.16550E 02	KIC

F-VALUE	135.2
RES. RMS	10.192978
NO. OF OBS.	83
CORR. COEF. SQRD	0.6253

OBS.	X	OBS. Y	PREDICTED Y	LOWER	UPPER	RESIDUAL
1	0.6869E 02	0.86[illegible]E 02	0.9067E 02	0.7306E 02	0.1083E 03	-0.4667E 01
2	0.7457E 02	0.120 E 03	0.9452E 02	0.7703E 02	0.1120E 03	0.2548E 02
3	0.7462E 02	0.880 E 02	0.9455E 02	0.7707E 02	0.1120E 03	-0.6550E 01
4	0.8499E 02	0.900 E 02	0.1013E 03	0.8403E 02	0.1186E 03	-0.1133E 02
5	0.8499E 02	0.880 E 02	0.1013E 03	0.8403E 02	0.1186E 03	-0.1333E 02
6	0.8986E 02	0.990 E 02	0.1045E 03	0.8729E 02	0.1217E 03	-0.5513E 01
7	0.8991E 02	0.101 E 03	0.1045E 03	0.8732E 02	0.1218E 03	-0.3545E 01
8	0.8993E 02	0.940 E 02	0.1046E 03	0.8733E 02	0.1218E 03	-0.1056E 02
9	0.9417E 02	0.970 E 02	0.1073E 03	0.9016E 02	0.1245E 03	-0.1033E 02
10	0.9442E 02	0.101 E 03	0.1075E 03	0.9032E 02	0.1247E 03	-0.6492E 01
11	0.9457E 02	0.101 E 03	0.1076E 03	0.9042E 02	0.1248E 03	-0.6594E 01
12	0.9908E 02	0.940 E 02	0.1105E 03	0.9341E 02	0.1277E 03	-0.1654E 02
13	0.9922E 02	0.113 E 03	0.1106E 03	0.9350E 02	0.1278E 03	0.2371E 01
14	0.9928E 02	0.119 E 03	0.1107E 03	0.9354E 02	0.1278E 03	0.8330E 01
15	0.1023E 03	0.105 E 03	0.1127E 03	0.9557E 02	0.1298E 03	-0.7670E 01
16	0.1023E 03	0.100 E 03	0.1127E 03	0.9557E 02	0.1298E 03	-0.1267E 02
17	0.1024E 03	0.105 E 03	0.1127E 03	0.9564E 02	0.1298E 03	-0.7744E 01
18	0.1026E 03	0.970 E 02	0.1128E 03	0.9571E 02	0.1299E 03	-0.1582E 02
19	0.1026E 03	0.138 E 03	0.1128E 03	0.9571E 02	0.1299E 03	0.2518E 02
20	0.1026E 03	0.119 E 03	0.1128E 03	0.9571E 02	0.1299E 03	0.6183E 01
21	0.1030E 03	0.101 E 03	0.1131E 03	0.9599E 02	0.1302E 03	-0.1209E 02
22	0.1031E 03	0.990 E 02	0.1132E 03	0.9605E 02	0.1303E 03	-0.141[illegible]E 02
23	0.1034E 03	0.120 E 03	0.1134E 03	0.9630E 02	0.1305E 03	0.6605E 01
24	0.1035E 03	0.113 E 03	0.1135E 03	0.9635E 02	0.1305E 03	-0.4514E 00
25	0.1036E 03	0.116 E 03	0.1135E 03	0.9641E 02	0.1306E 03	0.2494E 01
26	0.1036E 03	0.119 E 03	0.1135E 03	0.9641E 02	0.1306E 03	0.5494E 01
27	0.1061E 03	0.108 E 03	0.1151E 03	0.9835E 02	0.1322E 03	-0.7136E 01
28	0.1064E 03	0.139 E 03	0.1153E 03	0.9823E 02	0.1324E 03	0.2369E 02
29	0.1068E 03	0.113 E 03	0.1156E 03	0.9848E 02	0.1326E 03	-0.2563E 01
30	0.1069E 03	0.133 E 03	0.1156E 03	0.9856E 02	0.1327E 03	0.1736E 02
31	0.1071E 03	0.110 E 03	0.1158E 03	0.9872E 02	0.1329E 03	-0.5799E 01
32	0.1076E 03	0.120 E 03	0.1161E 03	0.9901E 02	0.1332E 03	0.3909E 01
33	0.1077E 03	0.132 E 03	0.1162E 03	0.9908E 02	0.1332E 03	0.1584E 02
34	0.1078E 03	0.116 E 03	0.1162E 03	0.9915E 02	0.1333E 03	-0.2278E 00
35	0.1103E 03	0.103 E 03	0.1179E 03	0.1008E 03	0.1350E 03	-0.1489E 02
36	0.1103E 03	0.111 E 03	0.1179E 03	0.1008E 03	0.1350E 03	-0.6885E 01
37	0.1103E 03	0.106 E 03	0.1179E 03	0.1008E 03	0.1350E 03	-0.1189E 02
38	0.1105E 03	0.122 E 03	0.1180E 03	0.1009E 03	0.1350E 03	0.4019E 01
39	0.1110E 03	0.118 E 03	0.1183E 03	0.1013E 03	0.1354E 03	-0.3467E 00
40	0.1112E 03	0.134 E 03	0.1184E 03	0.1014E 03	0.1355E 03	0.1557E 02
41	0.1113E 03	[illegible]	0.1185E 03	0.1015E 03	0.1356E 03	[illegible]

42	0.1113E 03	0.135 E 03	0.1185E 03	0.1015E 03	0.1356E 03	0.1648E 02
43	0.1114E 03	0.131 E 03	0.1186E 03	0.1015E 03	0.1357E 03	0.1240E 02
44	0.1119E 03	0.113 E 03	0.1189E 03	0.1019E 03	0.1360E 03	-0.5927E 01
45	0.1142E 03	0.122 E 03	0.1204E 03	0.1033E 03	0.1375E 03	0.1603E 01
46	0.1148E 03	0.117 E 03	0.1208E 03	0.1037E 03	0.1379E 03	-0.3808E 01
47	0.1148E 03	0.118 E 03	0.1208E 03	0.1037E 03	0.1379E 03	-0.2808E 01
48	0.1151E 03	0.118 E 03	0.1210E 03	0.1039E 03	0.1381E 03	-0.3004E 01
49	0.1152E 03	0.131 E 03	0.1211E 03	0.1040E 03	0.1382E 03	0.9900E 01
50	0.1183E 03	0.130 E 03	0.1231E 03	0.1060E 03	0.1401E 03	0.6920E 01
51	0.1188E 03	0.135 E 03	0.1234E 03	0.1063E 03	0.1405E 03	0.1159E 02
52	0.1189E 03	0.131 E 03	0.1235E 03	0.1065E 03	0.1406E 03	0.7484E 01
53	0.1189E 03	0.117 E 03	0.1235E 03	0.1065E 03	0.1406E 03	-0.6516E 01
54	0.1191E 03	0.132 E 03	0.1236E 03	0.1066E 03	0.1407E 03	0.8379E 01
55	0.1192E 03	0.132 E 03	0.1237E 03	0.1067E 03	0.1408E 03	0.8276E 01
56	0.1192E 03	0.117 E 03	0.1237E 03	0.1067E 03	0.1408E 03	-0.6724E 01
57	0.1212E 03	0.113 E 03	0.1249E 03	0.1078E 03	0.1420E 03	-0.1188E 02
58	0.1216E 03	0.133 E 03	0.1253E 03	0.1082E 03	0.1423E 03	0.7741E 01
59	0.1218E 03	0.130 E 03	0.1254E 03	0.1083E 03	0.1425E 03	0.4618E 01
60	0.1221E 03	0.134 E 03	0.1256E 03	0.1085E 03	0.1427E 03	0.8377E 01
61	0.1227E 03	0.132 E 03	0.1260E 03	0.1089E 03	0.1430E 03	0.6026E 01
62	0.1227E 03	0.137 E 03	0.1260E 03	0.1089E 03	0.1430E 03	0.1103E 02
63	0.1233E 03	0.123 E 03	0.1264E 03	0.1093E 03	0.1434E 03	-0.3370E 01
64	0.1276E 03	0.125 E 03	0.1292E 03	0.1121E 03	0.1463E 03	-0.4220E 01
65	0.1287E 03	0.136 E 03	0.1299E 03	0.1128E 03	0.1470E 03	0.6063E 01
66	0.1296E 03	0.137 E 03	0.1305E 03	0.1134E 03	0.1476E 03	0.6516E 01
67	0.1313E 03	0.136 E 03	0.1316E 03	0.1145E 03	0.1487E 03	0.4384E 01
68	0.1331E 03	0.146 E 03	0.1328E 03	0.1157E 03	0.1499E 03	0.1321E 02
69	0.1345E 03	0.135 E 03	0.1337E 03	0.1165E 03	0.1508E 03	0.1329E 01
70	0.1352E 03	0.136 E 03	0.1341E 03	0.1170E 03	0.1513E 03	0.1851E 01
71	0.1357E 03	0.143 E 03	0.1345E 03	0.1173E 03	0.1516E 03	0.8540E 01
72	0.1398E 03	0.142 E 03	0.1371E 03	0.1199E 03	0.1544E 03	0.4852E 01
73	0.1405E 03	0.121 E 03	0.1376E 03	0.1204E 03	0.1549E 03	-0.1664E 02
74	0.1435E 03	0.121 E 03	0.1396E 03	0.1223E 03	0.1568E 03	-0.1856E 02
75	0.1443E 03	0.148 E 03	0.1401E 03	0.1228E 03	0.1574E 03	0.7885E 01
76	0.1492E 03	0.151 E 03	0.1433E 03	0.1259E 03	0.1606E 03	0.7704E 01
77	0.1501E 03	0.141 E 03	0.1439E 03	0.1265E 03	0.1613E 03	-0.2890E 01
78	0.1519E 03	0.148 E 03	0.1451E 03	0.1277E 03	0.1625E 03	0.2891E 01
79	0.1559E 03	0.135 E 03	0.1471E 03	0.1296E 03	0.1646E 03	-0.1210E 02
80	0.1577E 03	0.1500E 03	0.1489E 03	0.1313E 03	0.1664E 03	0.1140E 01
81	0.1596E 03	0.136 E 03	0.1511E 03	0.1326E 03	0.1677E 03	-0.1413E 02
82	0.1603E 03	0.143 E 03	0.1506E 03	0.1330E 03	0.1682E 03	-0.7587E 01
83	0.1629E 03	0.143 E 03	0.1523E 03	0.1347E 03	0.1699E 03	-0.9286E 01

XMAX = 0.16292E 03 XMIN = 0.68686E 02

YMAX = 0.15100E 03 YMIN = 0.86000E 02

CABOT ESR ROTARY FORGED MUZZLE

ANOVA TABLE

SOURCE OF VARIATION	DF	SUM OF SQUARES CORR. FORM	SUM OF SQUARES ORIGINAL UNITS	MEAN SQUARE CORR. FORM	MEAN SQUARE ORIGINAL UNITS	F
TOTAL	8	1	0.1393E 09			
REGRESSION	2	0.932585E 00	0.129952E 09	0.466292E 00	0.649758E 08	0.415004E 02
RESIDUAL	6	0.674151E-01	0.939400E 07	0.112358E-01	0.156567E 07	

VARIABLE(S) ENTERED - 2, 1,

PERCENTAGE OF VARIATION EXPLAINED - 0.9326E 02

STANDARD DEVIATION OF RESIDUALS - 0.1251E 04

DETERMINANT VALUE - 0.98854E 00

VAR NO.	DECODED B COEFFICIENT	LIMITS UPPER/LOWER	STANDARD ERROR	PARTIAL F-TEST
1	-0.567766E 00	0.426385E 00 -0.156192E 01	0.406290E 00	0.195283E 01
2	0.330121E-01	0.421900E-01 0.238342E-01	0.375082E-02	0.774630E 02

CONSTANT TERM IN PREDICTION 0.713089E 04

CABOT ESR ROTARY FORGED MUZZLE

RESIDUAL ANALYSIS

OBS. NO.	OBSERVED Y	PREDICTED Y	RESIDUAL	NORMAL DEVIATE
1	0.20449E 05	0.19633E 05	0.81600E 03	0.65214E 00
2	0.12996E 05	0.12797E 05	0.19941E 03	0.15937E 00
3	0.20164E 05	0.21244E 05	-0.10798E 04	-0.86299E 00
4	0.13924E 05	0.13773E 05	0.15078E 03	0.12050E 00
5	0.21316E 05	0.19062E 05	0.22541E 04	0.18014E 01
6	0.13689E 05	0.15018E 05	-0.13289E 04	-0.10621E 01
7	0.13689E 05	0.13620E 05	0.69355E 02	0.55428E-01
8	0.12769E 05	0.13131E 05	-0.36178E 03	-0.28913E 00
9	0.22801E 05	0.23520E 05	-0.71907E 03	-0.57467E 00

CABOT ESR ROTARY FORGED BREECH

ANOVA TABLE

SOURCE OF VARIATION	DF	SUM OF SQUARES CORR. FORM	SUM OF SQUARES ORIGINAL UNITS	MEAN SQUARE CORR. FORM	MEAN SQUARE ORIGINAL UNITS	F
TOTAL	9	1	0.5830E 08			
REGRESSION	2	0.708568E 00	0.413122E 08	0.354284E 00	0.206561E 08	0.850967E 01
RESIDUAL	7	0.291432E 00	0.169916E 08	0.416331E-01	0.242737E 07	

VARIABLE(S) ENTERED - 2, 1,

PERCENTAGE OF VARIATION EXPLAINED - 0.7086E 02

STANDARD DEVIATION OF RESIDUALS - 0.1558E 04

DETERMINANT VALUE - 0.99704E 00

VAR NO.	DECODED B COEFFICIENT	LIMITS UPPER/LOWER	STANDARD ERROR	PARTIAL F-TEST
1	-0.236746E 00	0.122717E 01 -0.170066E 01	0.619095E 00	0.146234E 00
2	0.239638E-01	0.377094E-01 0.102183E-01	0.581306E-02	0.169943E 02

CONSTANT TERM IN PREDICTION 0.428917E 04

CABOT ESR ROTARY FORGED BREECH

RESIDUAL ANALYSIS

OBS. NO.	OBSERVED Y	PREDICTED Y	RESIDUAL	NORMAL DEVIATE
1	0.12100E 05	0.12683E 05	-0.58342E 03	-0.37447E 00
2	0.15129E 05	0.14792E 05	0.33672E 03	0.21612E 00
3	0.18496E 05	0.17068E 05	0.14279E 04	0.91652E 00
4	0.12769E 05	0.12390E 05	0.37923E 03	0.24341E 00
5	0.12769E 05	0.14807E 05	-0.20376E 04	-0.13078E 01
6	0.12321E 05	0.12849E 05	-0.52832E 03	-0.33910E 00
7	0.14161E 05	0.11544E 05	0.26165E 04	0.16794E 01
8	0.11236E 05	0.12849E 05	-0.16133E 04	-0.10355E 01
9	0.18225E 05	0.17736E 05	0.48861E 03	0.31362E 00
10	0.15625E 05	0.16111E 05	-0.48639E 03	-0.31219E 00

CABOT VD ROTARY FORGED MUZZLE

ANOVA TABLE

SOURCE OF VARIATION	DF	SUM OF SQUARES CORR. FORM	SUM OF SQUARES ORIGINAL UNITS	MEAN SQUARE CORR. FORM	MEAN SQUARE ORIGINAL UNITS	F
TOTAL	19	1	0.2850E 09			
REGRESSION	2	0.767828E 00	0.218801E 09	0.383914E 00	0.109401E 09	0.281108E 02
RESIDUAL	17	0.232172E 00	0.661600E 08	0.136572E-01	0.389176E 07	

VARIABLE(S) ENTERED - 2, 1,

PERCENTAGE OF VARIATION EXPLAINED - 0.7678E 02

STANDARD DEVIATION OF RESIDUALS - 0.1973E 04

DETERMINANT VALUE - 0.95905E 00

VAR NO.	DECODED B COEFFICIENT	LIMITS UPPER/LOWER	STANDARD ERROR	PARTIAL F-TEST
1	-0.176346E 00	0.761754E 00 -0.111444E 01	0.444639E 00	0.157295E 00
2	0.418977E-01	0.538222E-01 0.299732E-01	0.565195E-02	0.549520E 02

CONSTANT TERM IN PREDICTION -0.785514E 04

CABOT VD ROTARY FORGED MUZZLE

RESIDUAL ANALYSIS

OBS. NO.	OBSERVED Y	PREDICTED Y	RESIDUAL	NORMAL DEVIATE
1	0.17689E 05	0.17913E 05	-0.22421E 03	-0.11365E 00
2	0.17689E 05	0.13183E 05	0.45059E 04	0.22840E 01
3	0.18225E 05	0.17915E 05	0.30962E 03	0.15695E 00
4	0.18225E 05	0.15436E 05	0.27886E 04	0.14136E 01
5	0.17424E 05	0.18822E 05	-0.13982E 04	-0.70875E 00
6	0.17424E 05	0.14973E 05	0.24512E 04	0.12425E 01
7	0.98010E 04	0.12476E 05	-0.26752E 04	-0.13561E 01
8	0.98010E 04	0.88436E 04	0.95736E 03	0.48529E 00
9	0.10201E 05	0.12238E 05	-0.20367E 04	-0.10324E 01
10	0.10201E 05	0.98444E 04	0.35659E 03	0.18076E 00
11	0.88360E 04	0.11946E 05	-0.31101E 04	-0.15765E 01
12	0.88360E 04	0.94382E 04	-0.60221E 03	-0.30527E 00
13	0.94090E 04	0.11298E 05	-0.18888E 04	-0.95745E 00
14	0.94090E 04	0.90165E 04	0.39253E 03	0.19897E 00
15	0.10201E 05	0.10478E 05	-0.27737E 03	-0.14060E 00
16	0.10201E 05	0.92389E 04	0.96213E 03	0.48771E 00
17	0.14884E 05	0.13840E 05	0.10443E 04	0.52935E 00
18	0.14884E 05	0.14994E 05	-0.11026E 03	-0.55892E-01
19	0.16900E 05	0.18221E 05	-0.13209E 04	-0.66956E 00
20	0.16900E 05	0.17024E 05	-0.12425E 03	-0.62981E-01

CABOT VD ROTARY FORGED BREECH

ANOVA TABLE

SOURCE OF VARIATION	DF	SUM OF SQUARES CORR. FORM	SUM OF SQUARES ORIGINAL UNITS	MEAN SQUARE CORR. FORM	MEAN SQUARE ORIGINAL UNITS	F
TOTAL	19	1	0.9608E 08			
REGRESSION	2	0.723505E 00	0.695168E 08	0.361752E 00	0.347584E 08	0.222419E 02
RESIDUAL	17	0.276495E 00	0.265666E 08	0.162644E-01	0.156274E 07	

VARIABLE(S) ENTERED - 2, 1,

PERCENTAGE OF VARIATION EXPLAINED - 0.7235E 02

STANDARD DEVIATION OF RESIDUALS - 0.1250E 04

DETERMINANT VALUE - 0.79942E 00

VAR NO.	DECODED B COEFFICIENT	LIMITS UPPER/LOWER	STANDARD ERROR	PARTIAL F-TEST
1	-0.316791E 00	0.571698E 00 -0.120528E 01	0.421125E 00	0.565879E 00
2	0.233631E-01	0.321835E-01 0.145428E-01	0.418065E-02	0.312301E 02

CONSTANT TERM IN PREDICTION 0.876486E 04

CABOT VD ROTARY FORGED BREECH

RESIDUAL ANALYSIS

OBS. NO.	OBSERVED Y	PREDICTED Y	RESIDUAL	NORMAL DEVIATE
1	0.17956E 05	0.17264E 05	0.69223E 03	0.55374E 00
2	0.17956E 05	0.15214E 05	0.27417E 04	0.21932E 01
3	0.18496E 05	0.18515E 05	-0.19051E 02	-0.15239E-01
4	0.18496E 05	0.19865E 05	-0.13694E 04	-0.10955E 01
5	0.18769E 05	0.18979E 05	-0.21028E 03	-0.16821E 00
6	0.18769E 05	0.17565E 05	0.12044E 04	0.96345E 00
7	0.17424E 05	0.17565E 05	-0.14060E 03	-0.11247E 00
8	0.17424E 05	0.16857E 05	0.56675E 03	0.45336E 00
9	0.13456E 05	0.14873E 05	-0.14173E 04	-0.11337E 01
10	0.13456E 05	0.14150E 05	-0.69357E 03	-0.55481E 00
11	0.13924E 05	0.15139E 05	-0.12151E 04	-0.97198E 00
12	0.13924E 05	0.15814E 05	-0.18903E 04	-0.15121E 01
13	0.14161E 05	0.13426E 05	0.73513E 03	0.58805E 00
14	0.14161E 05	0.14150E 05	0.11430E 02	0.91430E-02
15	0.12769E 05	0.13373E 05	-0.60406E 03	-0.48321E 00
16	0.12769E 05	0.14089E 05	-0.13196E 04	-0.10556E 01
17	0.14400E 05	0.14028E 05	0.37211E 03	0.29767E 00
18	0.14400E 05	0.14735E 05	-0.33523E 03	-0.26816E 00
19	0.17161E 05	0.16065E 05	0.10957E 04	0.87652E 00
20	0.17161E 05	0.15366E 05	0.17950E 04	0.14359E 01

CABOT OD CONVENTIONALLY FORGED BREECH

ANOVA TABLE

SOURCE OF VARIATION	DF	SUM OF SQUARES CORR. FORM	SUM OF SQUARES ORIGINAL UNITS	MEAN SQUARE CORR. FORM	MEAN SQUARE ORIGINAL UNITS	F
TOTAL	11	1	0.1032E 09			
REGRESSION	2	0.593233E 00	0.611998E 08	0.296617E 00	0.305999E 08	0.656285E 01
RESIDUAL	9	0.406767E 00	0.419633E 08	0.451963E-01	0.466259E 07	

VARIABLE(S) ENTERED - 2, 1,

PERCENTAGE OF VARIATION EXPLAINED - 0.5932E 02

STANDARD DEVIATION OF RESIDUALS - 0.2159E 04

DETERMINANT VALUE - 0.47666E 00

VAR NO.	DECODED B COEFFICIENT	LIMITS UPPER/LOWER	STANDARD ERROR	PARTIAL F-TEST
1	0.206792E 01	0.479812E 01 -0.662284E 00	0.120688E 01	0.293588E 01
2	0.254520E-01	0.421730E-01 0.873094E-02	0.739149E-02	0.118571E 02

CONSTANT TERM IN PREDICTION -0.650504E 05

CABOT OD CONVENTIONALLY FORGED BREECH

RESIDUAL ANALYSIS

OBS. NO.	OBSERVED Y	PREDICTED Y	RESIDUAL	NORMAL DEVIATE
1	0.21904E 05	0.18986E 05	0.29180E 04	0.13514E 01
2	0.19881E 05	0.20457E 05	-0.57610E 03	-0.26680E 00
3	0.20449E 05	0.21330E 05	-0.88142E 03	-0.40820E 00
4	0.20449E 05	0.22049E 05	-0.15998E 04	-0.74087E 00
5	0.17161E 05	0.15884E 05	0.12769E 04	0.59134E 00
6	0.13689E 05	0.15884E 05	-0.21951E 04	-0.10166E 01
7	0.22500E 05	0.20612E 05	0.18879E 04	0.87433E 00
8	0.18496E 05	0.19286E 05	-0.78998E 03	-0.36585E 00
9	0.14641E 05	0.16046E 05	-0.14052E 04	-0.65075E 00
10	0.14641E 05	0.15336E 05	-0.69532E 03	-0.32201E 00
11	0.21904E 05	0.18176E 05	0.37284E 04	0.17266E 01
12	0.18225E 05	0.19894E 05	-0.16687E 04	-0.77280E 00

-ATIONAL FORGE VD ROTARY FORGED MUZZLE

ANOVA TABLE

SOURCE OF VARIATION	DF	SUM OF SQUARES CORR. FORM	SUM OF SQUARES ORIGINAL UNITS	MEAN SQUARE CORR. FORM	MEAN SQUARE ORIGINAL UNITS	F
TOTAL	8	1	0.23365 08			
REGRESSION	2	0.943254E 00	0.220380E 08	0.471627E 00	0.110190E 08	0.498675E 02
RESIDUAL	6	0.567456E-01	0.132579E 07	0.945761E-02	0.220965E 06	

VARIABLE(S) ENTERED - 2, 1,

PERCENTAGE OF VARIATION EXPLAINED - 0.9433E 02

STANDARD DEVIATION OF RESIDUALS - 0.4701E 03

DETERMINANT VALUE - 0.60820E 00

VAR NO.	DECODED B COEFFICIENT	LIMITS UPPER/LOWER	STANDARD ERROR	PARTIAL F-TEST
1	-0.119161E 01	-0.435146E 00 -0.194806E 01	0.309149E 00	0.148568E 02
2	0.125884E-01	0.190430E-01 0.613385E-02	0.263786E-02	0.227740E 02

CONSTANT TERM IN PREDICTION 0.353951E 05

-ATIONAL FORGE VD ROTARY FORGED MUZZLE

RESIDUAL ANALYSIS

OBS. NO.	OBSERVED Y	PREDICTED Y	RESIDUAL	NORMAL DEVIATE
1	0.10609E 05	0.10836E 05	-0.22721E 03	-0.48336E 00
2	0.73960E 04	0.70775E 04	0.31846E 03	0.67749E 00
3	0.11025E 05	0.10759E 05	0.26595E 03	0.56577E 00
4	0.11025E 05	0.10456E 05	0.56916E 03	0.12108E 01
5	0.11664E 05	0.11391E 05	0.27323E 03	0.58125E 00
6	0.77440E 04	0.80945E 04	-0.35046E 03	-0.74554E 00
7	0.10000E 05	0.10759E 05	-0.75905E 03	-0.16148E 01
8	0.81000E 04	0.81308E 04	-0.30770E 02	-0.65457E-01
9	0.77440E 04	0.78 33E 04	-0.59273E 02	-0.12610E 00

NATIONAL FORGE VD ROTARY FORGED BREECH

ANOVA TABLE

SOURCE OF VARIATION	DF	SUM OF SQUARES CORR. FORM	SUM OF SQUARES ORIGINAL UNITS	MEAN SQUARE CORR. FORM	MEAN SQUARE ORIGINAL UNITS	F
TOTAL	2	1	0.1529E 08			
REGRESSION	1	0.997264E 00	0.152447E 08	0.997264E 00	0.152447E 08	0.364541E 03
RESIDUAL	1	0.273567E-02	0.418191E 05	0.273567E-02	0.418191E 05	

VARIABLE(S) ENTERED - 2,

PERCENTAGE OF VARIATION EXPLAINED -- 0.9973E 02

STANDARD DEVIATION OF RESIDUALS - 0.2045E 03

DETERMINANT VALUE - 0.10000E 01

VAR NO.	DECODED B COEFFICIENT	LIMITS UPPER/LOWER	STANDARD ERROR	PARTIAL F-TEST
2	0.282512E-01	0.470521E-01 0.945025E-02	0.147967E-02	0.364541E 03

CONSTANT TERM IN PREDICTION 0.273973E 04

NATIONAL FORGE VD ROTARY FORGED BREECH

RESIDUAL ANALYSIS

OBS. NO.	OBSERVED Y	PREDICTED Y	RESIDUAL	NORMAL DEVIATE
1	0.19321E 05	0.19456E 05	-0.13529E 03	-0.66157E 00
2	0.19044E 05	0.18892E 05	0.15237E 03	0.74508E 00
3	0.14400E 05	0.14417E 05	-0.17070E 02	-0.83475E-01

MUZZLE   6R KIC   KIC   8.08.0

ANOVA TABLE

SOURCE OF VARIATION	DF	SUM OF SQUARES CORR. FORM	SUM OF SQUARES ORIGINAL UNITS	MEAN SQUARE CORR. FORM	MEAN SQUARE ORIGINAL UNITS	F
TOTAL	37	1	0.6936E 09			
REGRESSION	2	0.817977E 00	0.567345E 09	0.408988E 00	0.283673E 09	0.786414E 02
RESIDUAL	35	0.182[illegible]23E 00	0.126251E 09	0.520067E-02	0.360716E 07	

VARIABLE(S) ENTERED - 2, 1,

PERCENTAGE OF VARIATION EXPLAINED - 0.8180E 02

STANDARD DEVIATION OF RESIDUALS - 0.1899E 04

DETERMINANT VALUE - 0.75250E 00

VAR NO.	DECODED B COEFFICIENT	LIMITS UPPER/LOWER	STANDARD ERROR	PARTIAL F-TEST
1	-0.270986E 00	0.268296E 00 -0.810267E 00	0.265643E 00	0.104063E 01
2	0.298795E-01	0.352235E-01 0.245354E-01	0.263242E-02	0.128836E 03

CONSTANT TERM IN PREDICTION 0.180691E 04

MUZZLE BR KIC KIC 8.08.0

RESIDUAL ANALYSIS

OBS. NO.	OBSERVED Y	PREDICTED Y	RESIDUAL	NORMAL DEVIATE
1	0.20449E 05	0.20309E 05	0.14032E 03	0.73880E-01
2	0.12996E 05	0.14121E 05	-0.11250E 04	-0.59234E 00
3	0.20164E 05	0.22105E 05	-0.19408E 04	-0.10219E 01
4	0.13924E 05	0.15005E 05	-0.10810E 04	-0.56915E 00
5	0.21316E 05	0.20045E 05	0.12713E 04	0.66939E 00
6	0.13689E 05	0.16384E 05	-0.26954E 04	-0.14192E 01
7	0.13689E 05	0.14700E 05	-0.10108E 04	-0.53222E 00
8	0.12769E 05	0.14847E 05	-0.20783E 04	-0.10943E 01
9	0.22801E 05	0.23415E 05	-0.61417E 03	-0.32338E 00
10	0.17689E 05	0.16085E 05	0.16041E 04	0.84461E 00
11	0.17689E 05	0.12712E 05	0.49774E 04	0.26207E 01
12	0.18225E 05	0.15869E 05	0.23361E 04	0.12300E 01
13	0.18225E 05	0.14121E 05	0.41040E 04	0.21608E 01
14	0.17424E 05	0.16384E 05	0.10396E 04	0.54736E 00
15	0.17424E 05	0.13639E 05	0.37847E 04	0.19928E 01
16	0.98010E 04	0.12109E 05	-0.23083E 04	-0.12154E 01
17	0.98010E 04	0.95187E 04	0.28229E 03	0.14863E 00
18	0.10201E 05	0.11988E 05	-0.17874E 04	-0.94112E 00
19	0.10201E 05	0.10282E 05	-0.80641E 02	-0.42459E-01
20	0 88360E 04	0.11582E 05	-0.27458E 04	-0.14457E 01
21	0.88360E 04	0.97933E 04	-0.95730E 03	-0.50404E 00
22	0.94090E 04	0.11512E 05	-0.21032E 04	-0.11074E 01
23	0.94090E 04	0.98952E 04	-0.47622E 03	-0.25074E 00
24	0.10201E 05	0.10585E 05	-0.38419E 03	-0.20229E 00
25	0.10201E 05	0.97012E 04	0.49976E 03	0.26314E 00
26	0.14884E 05	0.13277E 05	0.16071E 04	0.84619E 00
27	0.14884E 05	0.14100E 05	0.78377E 03	0.41267E 00
28	0.16900E 05	0.16255E 05	0.64465E 03	0.33942E 00
29	0.16900E 05	0.15402E 05	0.14980E 04	0.78875E 00
30	0.10609E 05	0.13139E 05	-0.25301E 04	-0.13321E 01
31	0.73960E 04	0.59157E 04	0.14803E 04	0.77941E 00
32	0.11025E 05	0.11278E 05	-0.25330E 03	-0.13337E 00
33	0.11025E 05	0.11395E 05	-0.36987E 03	-0.19475E 00
34	0.11664E 05	0.11947E 05	-0.28260E 03	-0.14879E 00
35	0.77440E 04	0.66313E 04	0.11127E 04	0.58584E 00
36	0.10000E 05	0.11278E 05	-0.12783E 04	-0.67305E 00
37	0.81000E 04	0.84156E 04	-0.31563E 03	-0.16618E 00
38	0.77440E 04	0.84950E 04	-0.75101E 03	-0.39542E 00

BREECH   RR KIC   KIC .   8.08..

ANOVA TABLE

SOURCE OF VARIATION	DF	SUM OF SQUARES CORR. FORM	SUM OF SQUARES ORIGINAL UNITS	MEAN SQUARE CORR. FORM	MEAN SQUARE ORIGINAL UNITS	F
TOTAL	44	1	0.3892E 09			
REGRESSION	2	0.483396E 00	.138155E 09	.241698E 00	0.94.773E 08	0.19650IE 02
RESIDUAL	42	0.516604E 00	.2.1080E 09	0.123001E-01	0.478762E 07	

VARIABLE(S) ENTERED - 2, 1,

PERCENTAGE OF VARIATION EXPLAINED - 0.48345 02

STANDARD DEVIATION OF RESIDUALS - 0.2188E 04

DETERMINANT VALUE - 0.98362E 00

VAR NO.	DECODED B COEFFICIENT	LIMITS UPPER/LOWER	STANDARD ERROR	PARTIAL F-TEST
1	-0.8027735-01	0.41.6785 00 -0.571233F 00	0.243276E 00	0.108890E 00
2	0.124124E-.1	0.164746E-01 0.835028E-02	0.201285E-02	0.38.266E 02

CONSTANT TERM IN PREDICTION   0.920461E 04

BREECH BR KIC KIC 8.08.0

RESIDUAL ANALYSIS

OBS. NO.	OBSERVED Y	PREDICTED Y	RESIDUAL	NORMAL DEVIATE
1	0.21904E 05	0.18722E 05	0.31817E 04	0.14541E 01
2	0.19881E 05	0.19440E 05	0.44125E 03	0.20166E 00
3	0.20449E 05	0.20602E 05	-0.15265E 03	-0.69764E-01
4	0.20449E 05	0.20952E 05	-0.50298E 03	-0.22987E 00
5	0.17161E 05	0.16089E 05	0.10717E 04	0.48981E 00
6	0.13689E 05	0.16089E 05	-0.24003E 04	-0.10970E 01
7	0.22500E 05	0.20251E 05	0.22487E 04	0.10277E 01
8	0.18496E 05	0.20332E 05	-0.18359E 04	-0.83906E 00
9	0.14641E 05	0.18389E 05	-0.37484E 04	-0.17131E 01
10	0.14641E 05	0.18043E 05	-0.34022E 04	-0.15549E 01
11	0.21904E 05	0.19428E 05	0.24761E 04	0.11317E 01
12	0.18225E 05	0.19901E 05	-0.16760E 04	-0.76597E 00
13	0.19321E 05	0.14390E 05	0.49310E 04	0.22536E 01
14	0.19044E 05	0.14116E 05	0.49285E 04	0.22524E 01
15	0.14400E 05	0.12123E 05	0.22770E 04	0.10406E 01
16	0.17956E 05	0.16294E 05	0.16620E 04	0.75960E 00
17	0.17956E 05	0.15205E 05	0.27509E 04	0.12572E 01
18	0.18496E 05	0.16929E 05	0.15673E 04	0.71629E 00
19	0.18496E 05	0.17646E 05	0.84985E 03	0.38840E 00
20	0.18769E 05	0.17296E 05	0.14725E 04	0.67298E 00
21	0.18769E 05	0.16545E 05	0.22241E 04	0.10165E 01
22	0.17424E 05	0.16545E 05	0.87912E 03	0.40178E 00
23	0.17424E 05	0.16169E 05	0.12549E 04	0.57353E 00
24	0.13456E 05	0.15177E 05	-0.17206E 04	-0.78638E 00
25	0.13456E 05	0.14792E 05	-0.13362E 04	-0.61066E 00
26	0.13924E 05	0.15135E 05	-0.12111E 04	-0.55351E 00
27	0.13924E 05	0.15494E 05	-0.15698E 04	-0.71746E 00
28	0.14161E 05	0.14408E 05	-0.24667E 03	-0.11274E 00
29	0.14161E 05	0.14792E 05	-0.63116E 03	-0.28846E 00
30	0.12769E 05	0.14349E 05	-0.15797E 04	-0.72197E 00
31	0.12769E 05	0.14729E 05	-0.19598E 04	-0.89570E 00
32	0.14400E 05	0.14666E 05	-0.26589E 03	-0.12152E 00
33	0.14400E 05	0.15042E 05	-0.64169E 03	-0.29327E 00
34	0.17161E 05	0.15718E 05	0.14432E 04	0.65959E 00
35	0.17161E 05	0.15346E 05	0.18147E 04	0.82937E 00
36	0.12100E 05	0.14776E 05	-0.26764E 04	-0.12232E 01
37	0.15129E 05	0.15729E 05	-0.59996E 03	-0.27420E 00
38	0.18496E 05	0.17005E 05	0.14913E 04	0.68157E 00
39	0.12769E 05	0.14581E 05	-0.18125E 04	-0.82835E 00
40	0.12769E 05	0.15805E 05	-0.30362E 04	-0.13876E 01
41	0.12321E 05	0.14791E 05	-0.24704E 04	-0.11290E 01
42	0.14161E 05	0.14116E 05	0.45457E 02	0.20775E-01
43	0.11236E 05	0.14791E 05	-0.35554E 04	-0.16249E 01
44	0.18225E 05	0.17351E 05	0.87416E 03	0.39951E 00
45	0.15625E 05	0.16481E 05	-0.85604E 03	-0.39123E 00

ALL DATA BR KIC KIC 8.08.0

ANOVA TABLE

SOURCE OF VARIATION	DF	SUM OF SQUARES CORR. FORM	SUM OF SQUARES ORIGINAL UNITS	MEAN SQUARE CORR. FORM	MEAN SQUARE ORIGINAL UNITS	F
TOTAL	82	1	0.1281E 10			
REGRESSION	2	.644 243 00	0.824761E 09	0.322012E 00	0.412381E 09	0.723671E 02
RESIDUAL	80	.355976E 00	0.455876E 09	0.444970E-02	0.569845E 07	

VARIABLE(S) ENTERED - 2, 1,

PERCENTAGE OF VARIATION EXPLAINED - 0.6442E 02

STANDARD DEVIATION OF RESIDUALS - 0.2387E 04

DETERMINANT VALUE - 0.981415 [illegible]

VAR NO.	DECODED B COEFFICIENT	LIMITS UPPER/LOWER	STANDARD ERROR	PARTIAL F-TEST
1	0.147939E [illegible]	0.538761E 00 -0.242882E 00	0.196383E 00	0.567491E 00
2	0.192094E-01	0.224512E-01 0.159675E-01	0.162900E-02	0.139055E 03

CONSTANT TERM IN PREDICTION -0.292888E 04

ALL DATA BR KIC KIC 8.08.0

RESIDUAL ANALYSIS

OBS. NO.	OBSERVED Y	PREDICTED Y	RESIDUAL	NORMAL DEVIATE
1	0.20449E 05	0.18496E 05	0.19526E 04	0.81795E 00
2	0.12996E 05	0.14518E 05	-0.15224E 04	-0.63775E 00
3	0.20164E 05	0.20[illegible]E 05	0.64418E 02	0.26985E-01
4	0.13924E 05	0.15[illegible]87E 05	-0.11627E 04	-0.48707E 00
5	0.21316E 05	0.18662E 05	0.26539E 04	0.11118E 01
6	0.13689E 05	0.163[illegible]9E 05	-0.26199E 04	-0.10975E 01
7	0.13689E 05	0.14670E 05	-0.98117E 03	-0.41102E 00
8	0.12769E 05	0.15548E 05	-0.27785E 04	-0.11640E 01
9	0.22801E 05	0.19948E 05	0.28535E 04	0.11953E 01
10	0.17689E 05	0.15343E 05	0.23462E 04	0.98283E 00
11	0.17689E 05	0.13174E 05	0.45148E 04	0.18913E 01
12	0.18225E 05	0.15655E 05	0.257[illegible]E 04	0.1[illegible]766E 01
13	0.18225E 05	0.14518E 05	0.37066E 04	0.15527E 01
14	0.17424E 05	0.163[illegible]9E 05	0.11151E 04	0.46712E 00
15	0.17424E 05	0.14544E 05	0.28799E 04	0.12064E 01
16	0.98010E 04	0.13[illegible]5E 05	-0.32037E 04	-0.13421E 01
17	0.98010E 04	0.11339E 05	-0.15383E 04	-0.64440E 00
18	0.10201E 05	0.12818E 05	-0.26168E 04	-0.10962E 01
19	0.10201E 05	0.11721E 05	-0.15195E 04	-0.63655E 00
20	0.88360E 04	0.12997E 05	-0.41611E 04	-0.17431E 01
21	0.88360E 04	0.11847E 05	-0.30113E 04	-0.12615E 01
22	0.94090E 04	0.12[illegible]81E 05	-0.26722E 04	-0.11194E 01
23	0.94090E 04	0.11[illegible]35E 05	-0.16263E 04	-0.68127E 00
24	0.10201E 05	0.12245E 05	-0.2[illegible]443E 04	-0.85636E 00
25	0.10201E 05	0.11677E 05	-0.14760E 04	-0.61830E 00
26	0.14884E 05	0.13322E 05	0.15616E 04	0.65418E 00
27	0.14884E 05	0.13852E 05	0.10323E 04	0.43243E 00
28	0.16900E 05	0.15561E 05	0.13390E 04	0.56092E 00
29	0.16900E 05	0.15[illegible]12E 05	0.18876E 04	0.79075E 00
30	0.10609E 05	0.13127E 05	-0.25182E 04	-0.10549E 01
31	0.73960E 04	0.86972E 04	-0.13012E 04	-0.54509E 00
32	0.11025E 05	0.11720E 05	-0.69455E 03	-0.29096E 00
33	0.11025E 05	0.1199[illegible]E 05	-0.87484E 03	-0.36648E 00
34	0.11664E 05	0.12[illegible]45E 05	-0.38059E 03	-0.15940E 00
35	0.77440E 04	0.89434E 04	-0.11994E 04	-0.50243E 00
36	0.1[illegible]E 05	0.11720E 05	-0.17196E 04	-0.72034E 00
37	0.81000E 04	0.10314E 05	-0.22044E 04	-0.92345E 00
38	0.77440E 04	0.10463E 05	-0.27194E 04	-0.11392E 01
39	0.21904E 05	0.19667E 05	0.22375E 04	0.93730E 00
40	0.19881E 05	0.20777E 05	-0.89582E 03	-0.37527E 00
41	0.20449E 05	0.22391E 05	-0.19420E 04	-0.81352E 00
42	0.20449E 05	0.22933E 05	-0.24841E 04	-0.10406E 01
43	0.17161E 05	0.15872E 05	0.12893E 04	0.54010E 00
44	0.13689E 05	0.15872E 05	-0.21827E 04	-0.91436E 00
45	0.22500E 05	0.21849E 05	0.65118E 03	0.27279E 00
46	0.18496E 05	0.21792E 05	-0.32957E 04	-0.13806E 01
47	0.14641E 05	0.18876E 05	-0.42351E 04	-0.17741E 01
48	0.14641E 05	0.1834[illegible]E 05	-0.36993E 04	-0.15497E 01
49	0.21904E 05	0.20483E 05	0.14207E 04	0.59516E 00
50	0.18225E 05	0.21307E 05	-0.30817E 04	-0.12909E 01
51	0.19321E 05	0.12416E 05	0.69045E 04	0.28924E 01
52	0.19044E 05	0.12[illegible]81E 05	0.69628E 04	0.29168E 01
53	0.14400E 05	0.90677E 04	0.53123E 04	0.22254E 01
54	0.17956E 05	0.16[illegible]01E 05	0.19548E 04	0.81888E 00
55	0.17956E 05	0.14316E 05	0.36399E 04	0.15248E 01
56	0.18496E 05	0.16891E 05	0.16052E 04	0.67245E 00
57	0.18496E 05	0.18[illegible]01E 05	0.49493E 03	0.20733E 00
58	0.187[illegible]E 05	[illegible]	[illegible]	[illegible]

59	0.18769E 05	0.16671E 05	0.2[illegible]977E 04	0.87876E 0[illegible]
60	0.17424E 05	0.16671E 05	0.75273E 03	0.31533E 0[illegible]
61	0.17424E 05	0.16[illegible]9[illegible]E 05	0.13343E 04	0.55896E 0[illegible]
62	0.13456E 05	0.14744E 05	-0.12883E 04	-0.53969E 0[illegible]
63	0.13456E 05	0.14149E 05	-0.69329E 03	-0.29043E 0[illegible]
64	0.13924E 05	0.14115E 05	-0.191[illegible]2E 03	-0.8[illegible]02[illegible]E-01
65	0.13924E 05	0.1467[illegible]E 05	-0.74617E 03	-0.31258E 0[illegible]
66	0.14161E 05	0.13554E 05	0.60674E 03	0.25417E 00
67	0.14161E 05	0.14149E 05	0.11711E 02	0.49059E-02
68	0.12769E 05	0.13[illegible]67E 05	-0.59848E 03	-0.25071E 0[illegible]
69	0.12769E 05	0.13756E 05	-0.11868E 04	-0.49715E 0[illegible]
70	0.14400E 05	0.13763E 05	0.63664E 03	0.26670E 00
71	0.14400E 05	0.14345E 05	0.55[illegible]63E 02	0.23066E-01
72	0.17161E 05	0.152[illegible][illegible]E 05	0.18642E 04	0.78094E 0[illegible]
73	0.17161E 05	0.14722E 05	0.24391E 04	0.10218E 01
74	0.12100E 05	0.13[illegible]60E 05	-0.14599E 04	-0.61155E 00
75	0.15129E 05	0.14136E 05	0.99313E 03	0.41603E 0[illegible]
76	0.18496E 05	0.16733E 05	0.17629E 04	0.73847E 0[illegible]
77	0.12769E 05	0.12943E 05	-0.214[illegible]5E 03	-0.89667E-01
78	0.12769E 05	0.14696E 05	-0.19271E 04	-0.80729E 00
79	0.12321E 05	0.13127E 05	-0.6[illegible]613E 03	-0.33772E 0[illegible]
80	0.14161E 05	0.12[illegible]91E 05	0.20798E 04	0.87124E 0[illegible]
81	0.11236E 05	0.13127E 05	-0.18912E 04	-0.79224E 0[illegible]
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